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Soil Survey

Kittitas County Washington

By
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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
Washington Agricultural Experiment Station

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HOW TO USE THE SOIL SURVEY REPORT

SOIL SURVEYS PROVIDE a foundation for all land use programs. This report and the accompanying map present information both general and specific about the soils, the crops, and the agriculture of the area surveyed. The individual reader may be interested in the whole report or only in some particular part. Ordinarily he will be able to obtain the information he needs without reading the whole. Prepared for both general and detailed use, the report is designed to meet the needs of a wide variety of readers of three general groups: (1) Those interested in the area as a whole; (2) those interested in specific parts of it; and (3) students and teachers of soil science and related agricultural subjects. Attempt has been made to meet the needs of all three groups by making the report comprehensive for purposes of reference.

Readers interested in the area as a whole include those concerned with general land use planning—the placement and development of highways, power lines, urban sites, industries, community cooperatives, resettlement projects, and areas for forest and wildlife management and for recreation. The following sections are intended for such users: (1) County Surveyed, in which physiography, vegetation, water supply, population, cultural developments, transportation, and industries are discussed; (2) Agricultural History and Statistics, in which a brief history and the present status of the agriculture are described; (3) Productivity Ratings, in which the soils are grouped according to their relative physical suitability for agricultural use; (4) Land Use and Agricultural Methods, in which the present uses of the soils are described and suggestions made for improvement, and (5) Irrigation, Drainage, and Alkali.

Readers interested chiefly in specific areas—such as some particular locality, farm, or field—include farmers, agricultural technicians interested in planning operations in communities or on individual farms, and real estate agents, land appraisers, prospective purchasers and tenants, and farm loan agencies. These readers should (1) locate on the map the tract with which concerned; (2) identify the soils on the tract by locating in the legend on the margin of the map the symbols and colors that represent them; and (3) locate in the table of contents in the section on Soils and Crops the page where each type is described in detail and information given as to its suitability for use and its relations to crops and agriculture. They will also find useful specific information relating to the soils in the sections on Productivity Ratings; Land Use and Agricultural Methods; and Irrigation, Drainage, and Alkali.

Students and teachers of soil science and allied subjects, including crop production, forestry, animal husbandry, economics, rural sociology, geography, and geology, will find their special interest in the section on Morphology and Genesis of Soils. They will also find useful information in the section on Soils and Crops, in which are presented the general scheme of classification of the soils of the area and a detailed discussion of each type. For those not already familiar with the classification and mapping of soils, these subjects are discussed under Soil Survey Methods and Definitions. Teachers of other subjects will find the sections on County Surveyed, Agricultural History and Statistics, Productivity Ratings, and the first part of the section on Soils and Crops, of particular value in determining the relations between their specific subjects and the soils of the area.

This publication on the soil survey of Kittitas County, Wash., is a cooperative contribution from the—

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SOIL SURVEY OF KITTITAS COUNTY, WASHINGTON

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SUMMARY

Kittitas County is in central Washington and extends from the crest of the Cascade Mountains eastward to the Columbia River. The total area comprises 2,315 square miles, or 1,481,600 acres. It

[1] The field work for this survey was done while the Division was a part of the Bureau of Chemistry and Soils.

includes the mountainous region embracing the headwaters of the upper Yakima River and its tributaries, the rugged plateau extending eastward to the Columbia River, and the basin of the Kittitas Valley. Over one-half of the county consists of timbered mountainous land, and one-third is steep broken land and scabland, which are suitable only for grazing. The rest of the county consists of agricultural lands lying principally in the basin of the Kittitas Valley and the valley of the upper Yakima River.

All the most desirable farm lands are occupied and highly developed. The larger part is irrigated.

The first white settlers came to the Kittitas Valley in 1867. Ellensburg, the county seat and principal town, is 90 miles by air line southeast of Seattle.

Transportation facilities are excellent, as the county is crossed by the main lines of the Northern Pacific Railway and the Chicago, Milwaukee, St. Paul & Pacific Railroad, in addition to paved highways.

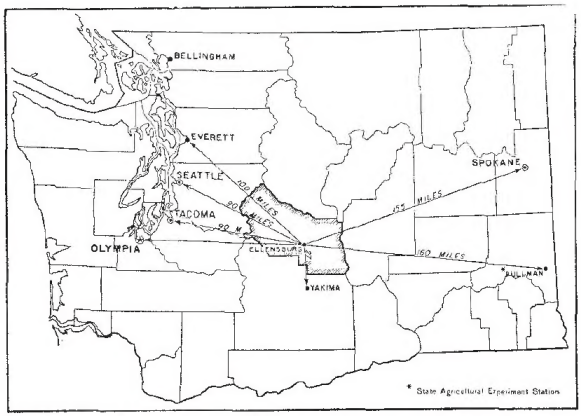


FIGURE 1.—Location of Kittitas County in Washington.

The cities on Puget Sound are the principal markets for hay, grain, and livestock products. Some wheat is milled within the county.

The climate is mild and continental in character, but the amount of precipitation, length of growing season, and mean temperature vary greatly from place to place. The annual precipitation ranges from 7.20 inches at Trinidad, Grant County and 8.89 inches at Ellensburg to 92.69 inches at Snoqualmie Pass. A large part of the precipitation comes in the winter and early spring. The summers are very dry, even in the humid part of the area.

Irrigation is necessary for the optimum production of most crops, although the rainfall is sufficient in small areas in the uplands to produce wheat every other year if summer-fallowing is practiced.

Agriculture is limited by the short seasons and cool nights to general farming and dairying. Alfalfa, clover and timothy, wheat, oats, and barley are grown for sale and for feeding on the farm. Dairying is one of the most profitable farm enterprises and is increasing in importance. The production of potatoes has increased fourfold in the 10 years 1929 to 1939. Yields range from 5 to 20 tons an acre. Peas are grown for seed on a limited acreage. Commercial apple orchards are unimportant and are confined to one small frost-free area.

Crossbred range sheep are grazed on the arid ranges during spring and fall, in the forest in summer, and in the valleys in winter. Beef cattle are kept on several outlying ranches.

Improved methods and machinery are in general use, and the farms on the better lands are well improved. Improved land under irrigation sells at good prices.

The agriculture of Kittitas County is largely adjusted to climate, relief, water supply, and drainage conditions rather than to soil types.

The soils of the semi-arid uplands and terraces in general have adequate surface drainage. They include members of the Renslow, Selah, Manastash, Reeser, Taneum, Simcoe, and Waha series.

The soils of the semiarid lowlands and stream bottoms, which are in part imperfectly drained, include members of the Onyx, Yakima, Naches, Esquatzel, Kittitas, Ahtanum, Woldale, Nanum, and Wenas series. The Ahtanum soils are seriously affected with so-called alkali, and the Esquatzel, Kittitas, and Woldale to a less extent.

The soils of the humid and subhumid uplands and stream valleys occupy timbered areas and prairies.

The Pend Oreille, Roslyn, and Volke soils of the humid timbered areas are moderately productive. The light-colored soils of the well-drained uplands and terrace soils of the timbered areas include members of the Teanaway, Cle Elum, Volperie, and Bertolotti series, which are comparatively infertile and are better suited to the production of timber than to agriculture. Lower lying terrace soils having a less dense cover of timber include the Springdale and Roslyn soils. The imperfectly drained soils of the timbered areas include members of the Volke and Quicksell series.

The well-drained soils of the prairies belong to the Swauk and Garrison series. The Swauk soils are used for the production of wheat without irrigation. The Latah and Peoh soils of the prairie and park areas are imperfectly drained.

The well-drained soils are suited to all the common crops of the region, including alfalfa; the imperfectly drained soils in general are limited to the production of grain, clover, grass hay, and pasture.

The organic soils and miscellaneous soils and land types are for the most part nonagricultural and are best utilized for forestry and grazing.

COUNTY SURVEYED

Kittitas County is in the central part of the State of Washington (fig. 1). It ranges from 35 to 40 miles in width and extends from the crest of the Cascade Range on the west to the Columbia River on the east, a distance of about 80 miles. The northern boundary follows the crest of the Wenatchee Mountains and the fifth standard parallel of latitude. The Naches River, together with township and range lines, forms the boundary between this county and Yakima County on the south. Ellensburg, the county seat, is in the Kittitas Valley and is 90 miles southeast of Seattle by air line. The county comprises 2,315 square miles, or 1,481,600 acres.

In this survey most of the county is covered by a small-scale reconnaissance map, but the soils of the settled agricultural districts in the Kittitas Valley, in the valleys of the upper Yakima River and its tributaries, and in a small strip along the Columbia River are mapped in detail. About 514 square miles, or 328,960 acres, are included in the detailed survey. The part of the county covered by reconnaissance

is largely nonagricultural. Nearly one-half of the county is included within the Wenatchee and Snoqualmie National Forests.

Kittitas County lies partly within the Cascade Range and partly within the borderland between the mountains and the Columbia plain. It embraces a wide range in climatic conditions and physiographic features. The Cascade Range is flanked for many miles on the east by southeastward-trending upfolded ridges, which extend to or beyond the Columbia River. The mountain flanks and foothills of the south side of the Wenatchee Mountains, the most important of the uplifts, comprise the northern one-third of the county. The western and southern parts also are occupied by mountains and ridges. The basin of the upper Yakima River lies wholly within the county and drains all its area except the extreme southwestern part, which is drained by tributaries of the Naches River and by North Fork Wenas Creek, and the extreme eastern edge, which is dissected by short, deep canyons draining into the Columbia River (pl. 1.)

The valley of the upper Yakima River extends southeastward from Snoqualmie Pass through the central part of the county, dividing the northern and southern elevated parts, which have been greatly dissected by many tributary streams and sculptured by erosion into areas of bold and rugged relief. In the headwater drainage area of the northwestern corner of the county are a number of glacial lakes. The three largest of these are prominent physiographic features and are of considerable economic importance as storage reservoirs; dams have been built to impound large reserves of irrigation water. The Yakima River forms the outlet of Lake Keechelus, the westernmost of these lakes. Ten miles below this outlet the Yakima River is joined by the Kachess River, which flows southward 2 miles from Lake Kachess, the largest of these bodies of water, and 10 miles farther down its course it is joined by the largest and most important tributary stream, the Cle Elum River flowing in from Lake Cle Elum. The Cle Elum River, having its source under high peaks in an area of heavy snowfall and several small glaciers, supplies the larger part of the flow of the Yakima River during the summer. The Teanaway River, Swauk Creek, and a number of small creeks to the eastward drain the southern slopes of the Wenatchee Mountains and furnish irrigation water to large areas of farm land. Taneum, Manastash, and Umtanum Creeks flow eastward between the parallel ridges of the southern part of the county and join the Yakima River from the west.

The Kittitas Valley is a downfolded mountain basin lying in the east-central part of the county, roughly oval in shape, about 25 miles long from northwest to southeast, and 14 miles wide. It slopes southward from the foothills of the Wenatchee Mountains toward the Manastash Ridge and its eastward extension, the Saddle Mountains. The eastern end of this basin is divided by a low ridge into two fishtaillike extensions, the northern called The Park and the southern the Badger Pocket. The Kittitas Valley is separated from the valleys of the upper Yakima and Teanaway Rivers by a broken, dissected plateau formed by the upturned rim of the basin that ends in the bold northward-facing escarpments of the ridges between Green Canyon and Swauk Creek, Lookout Mountain, and Cle Elum

Ridge. The Yakima River flows in a canyon through this plateau and after crossing the southwest margin of the Kittitas Valley, turns southward, cutting across the Manastash and Umtanum Ridges through a deep, tortuous canyon.

The canyon-cutting power of the Yakima River has been so effective that its present channel and bordering flood plain within the valley are entrenched many feet below the basin floor. Directly across from Ellensburg the river flows under a 30-foot escarpment it has cut into the alluvial fan of Manastash Creek. South of Thorp three escarpments and three terrace levels record the progress of the river in cutting and lowering its valley. The smaller drainageways of the valley converge at the southern side of the basin, where the river flows into its canyon. These drainageways have greatly complicated the surface of the basin by local erosion and redeposition of material.

The small streams that flow from surrounding uplifted areas have shifted their courses widely while spreading detritus over the valley. Near the northern and western margins of the basin a deposit of coarse rubble of angular basalt fragments overlaps the old basin surface, and farther out toward the river bottom the streams have dissected and eroded away parts of the older land surface, leaving isolated tongue-shaped remnants above the present influence of these streams. The long, low hill east of Thrall, Craigs Hill at Ellensburg, the wide tongue of gravel scabland that extends out into the valley between Reeser and Wilson Creeks, and the high bench west of Dry Creek are remnants of the old basin floor.

Squaw Creek, an intermittent stream, enters the canyon of the Yakima River from the east, its drainage basin occupying the down fold between the Saddle Mountains and the eastward continuation of the Umtanum Ridge. Except for narrow strips of valley along the west bank of the Columbia River, the eastern part of the county is a barren, arid plateau of rocky ridges and canyons.

The vegetation shows striking variation in different parts of the county, owing to differences in elevation, temperature, and precipitation. Sagebrush is the dominant plant over the arid ranges of the southeastern third of the county. It is said that at the time of settlement a good stand of bunchgrass covered the uplands, and tall ryegrass in the valleys furnished winter feed for herds of cattle. Since then, however, these grasses have been depleted by overgrazing, and good stands of bunchgrass now grow only in places far removed from water and at higher elevations. An introduced small drought-resistant annual grass, downy chess (popularly called cheat), has spread over the overgrazed arid ranges and is the dominant grass associated with sagebrush. It furnishes early spring feed for sheep.

The higher foothills and mountains are covered with coniferous forests. Open stands of pine extend through the narrow transitional zone adjoining the sagebrush area. Thickets of Douglas-fir, here and there enclosing small open meadows (pl. 2), grow on north and east exposures. Up the mountain slopes and to the westward almost unbroken forests of mixed conifers extend to the timber line on the highest peaks. Douglas-fir is the dominant tree throughout most of this area, and there are some white firs (*Abies* spp.), western

white pine, and western larch (locally called tamarack) trees. Engelmann spruce, western redcedar (giant arborvitae), and lodgepole pine grow on the moist lower slopes of the higher mountains; whereas alpine fir, whitebark pine, Alaska cedar, and mountain hemlock (locally called black hemlock) occupy the higher altitudes and exposed positions near the timber line. The fine stands of merchantable timber that once covered the foothills and upper valleys have now been almost entirely logged off except in areas within national forests. An almost impenetrable growth of young trees and brush now covers the greater part of the cut-over lands that have not been cleared for farming.

The banks of the streams are fringed with deciduous trees, including cottonwood, willow, and aspen. Dense thickets of willow, western thornapple or hawthorn, and small dogwood are common on wet slopes and stream bottoms.

Although there are many streams in the area, the alluvial bottom lands of the stream valleys are narrow and of small extent. Most of the arable land is on terraces, old alluvial fans, and the slopes of valley basins. Glacial terraces of several levels and areas of boulder till containing many large erratic boulders occur in the valleys of the upper Yakima and Teanaway Rivers below an approximate elevation of 3,000 feet above sea level. These deposits are from mountain glaciers, very probably of three distinct periods. The oldest probably extended to the northwestern margin of the Kittitas Valley or perhaps farther and left deposits of boulder till on Thorp Prairie and the south slopes of Lookout Mountain. The glaciers of the next period extended down the Yakima River to the present mouth of the Cle Elum River and down the Teanaway River to Swauk Creek, leaving terminal moraine deposits of boulder till south of Nelson and on Swauk Prairie. The last glaciers were smaller than the first, and terminal deposits made by them dammed the valleys, forming the present lakes.

The glacial age was a time of heavy precipitation, intense erosion, and canyon cutting. During more recent geologic times, loessial deposits of wind-borne dust have been laid down in the eastern part of the county, particularly in protected situations on the north slopes of the ridges and adjacent basin lowlands. Subsequent erosion has removed part of this mantle of loess.

Elevations[2] range from 475 feet above sea level at the head of Priest Rapids on the Columbia River, in the extreme southeastern part of the county, to nearly 8,000 feet on Mount Daniel and Ingalls Peak in the northwest. The elevation at Ellensburg is 1,510 feet, at Cle Elum 1,911, and at Easton 2,166. Snoqualmie Pass through the Cascades is only 3,003 feet high; Blewett Pass over the Wenatchee Mountains is 4,071 feet high; and the Naches Pass at the southwestern corner of the county is 4,823 feet high. The peaks along the crest of the mountains range from 5,000 to 8,000 feet above sea level.

The first white settlers came to the Kittitas Valley in 1867, and soon after the discovery of gold on Swauk and Peshastin Creeks several hundred white people were living in the region. Kittitas County was separated from Yakima County and organized under

[2] Taken from topographic maps of the U. S. Geological Survey.

territorial government in 1882. At this time it extended northward to the Wenatchee River. The discovery of coal and the development of mines in the vicinity of Roslyn during the period 1883–86, and the construction of the Northern Pacific Railway through to Puget Sound greatly stimulated further settlement. The census of 1890 reported a population of 8,777, and the census of 1900, 9,704. The smallness of the increase was due in part to the reduced size of the county after the creation of Chelan County in 1899, at which time the present boundaries were established. During the next decade the population nearly doubled; the census of 1910 reported 18,561 inhabitants. Between 1910 and 1920 the population decreased to 17,737. This was a period of retrenchment after the rapid expansion in many parts of the Northwest. In the coal mines men were replaced by machinery, logging operations were curtailed by diminishing stands of easily accessible timber, and homesteads were abandoned where the land was too poor or too dry for profitable agriculture without irrigation. By 1940 the population of the county had increased to 20,230 as a result of the settlement of irrigated lands under the Highline Canal and the immigration of drought-stricken farmers from the Middle West to the Pacific Northwest.

The settlers of this county were largely of pioneer stock, but a few came originally from northern and western Europe. Some came from Yakima and Klickitat Counties; others came into the Northwest from States east of the Rockies. The people of the Kittitas Valley are largely of the same stock that originally settled there.

The operation of the coal mines, however, has attracted many southern and eastern Europeans, mostly Italians and Croatians. The towns of Cle Elum, Roslyn, and Ronald have a high proportion of these nationalities. A few Negroes live in Roslyn.

Of the population reported in 1940, 14,286 were classed as rural and 5,944 as urban. There were 2,347 native whites, 17,667 foreign-born whites, 155 Negroes, and 61 of other races. In 1940 Ellensburg had a population of 5,944. Kittitas and Thorp are small towns in the Kittitas Valley. Cle Elum, having a population of 2,230, is a railway and highway town about 25 miles northwest of Ellensburg; and nearby Roslyn, with a population of 1,743, is the center of the coal-mining industry. South Cle Elum, Easton, and Ronald are smaller towns in the western part of the county.

All but the more sparsely settled parts of the county are adequately served by telephones, churches, and schools. During recent years many small rural schools have been discontinued in favor of consolidated schools situated in towns, to which children are transported by bus. There are high schools at Ellensburg, Kittitas, Thorp, Cle Elum, and Easton. The Central Washington College of Education is located at Ellensburg. The United States Forest Service maintains telephones in many parts of the mountain forests. Electric power and light service is well distributed throughout the settled districts and now reaches about 95 percent of the county farms.

Transportation facilities are well developed. The main lines of the Northern Pacific Railway and of the Chicago, Milwaukee, St. Paul & Pacific Railroad cross the country. Paved Federal and State high-

ways connect the towns of this county with Yakima, Wenatchee, Spokane, and the cities on Puget Sound. Much farm produce is shipped by motortruck to the Puget Sound district over United States Highway No. 10. Except for very short periods during storms, Snoqualmie Pass is kept open throughout the winter, and cross-State and transcontinental traffic on this road is continuous. All settled parts of the county are served adequately by graveled roads, which are kept open except during temporary periods of heavy snowfall. Many miles of forest road have been built for use in fire protection by the United States Forest Service with the aid of the Civilian Conservation Corps.

Of the industries other than agriculture, mining is the most important. Nearly a million tons of coal a year is taken from the mines near Roslyn for the use of the Northern Pacific Railway. Coal for domestic use is shipped by railroad or truck from a number of independent mines to other parts of the State. Gold mining is carried on in a small way on upper Swauk Creek and its tributaries near the hamlet of Liberty. Diatomaceous earth has been mined commercially from extensive deposits in the Squaw Creek basin, 15 miles southeast of Kittitas.

Several sawmills are operated in the county, and logging camps are maintained along Swauk Creek and in other yellow pine and mixed forest areas.

The business of serving the trade of the motor and the heavy trucking traffic that passes over the highway to Puget Sound has grown to the proportion of an industry. The towns of Cle Elum and Easton are in a large measure supported by trade derived directly from the highway and its maintenance.

There are a number of fur farms in the county. Climatic conditions, particularly in the mountain districts, favor further development of this industry.

CLIMATE

The climate of Kittitas County is essentially continental in character. Although the tempering effects of the prevailing westerly winds from the ocean are not entirely shut off by the Cascade Mountains, extremes of both heat and cold are in marked contrast with the equable temperatures of the region west of the mountains. Temperatures of 110° and −31° F. have been recorded at Ellensburg, but these extreme temperatures are exceptional. The cold of the winter is usually broken by mild west winds, often melting the snow in midwinter. Hot spells during the summer are of short duration, and the heat is seldom oppressive. There is a high proportion of sunshine, and the dry atmosphere is healthful and invigorating.

The moist air from the ocean is chilled and gives up the greater part of its moisture as it rises over the mountains, but while descending it becomes warm again and regains its capacity to hold and take up moisture. Thus as the air moves eastward down the eastern side of the Cascade Mountains it becomes drier and the precipitation becomes less and less. The precipitation is high over the mountains, coming mostly as snow in winter, but it decreases greatly with lower elevations, and the lower valleys are very dry.

Small mountain meadow valley in the western part of the county, surroun

A, Roadside cut in Selah loam showing slablike caliche hardpan over cemented gravel. *B*, Native vegetation, mostly sagebrush, on Selah loam. (Courtesy of Washington State Works Progress Administration.)

The mean annual precipitation at Snoqualmie Pass is 92.69 inches; at Ellensburg, an air-line distance of but 50 miles, it is 8.89 inches; and at Trinidad, Grant County, on the Columbia River, it is about 7.20 inches.

About 75 percent of the precipitation occurs between October 1 and March 1. The ground dries out during the summer and early fall, even in the mountain forests, and the fire hazard is serious. Irrigation is necessary for most crops.

Except along the Columbia River, the growing season is short. Although extremes of heat are experienced occasionally, the nights are cool and the mean temperatures low. Frosts have been recorded in every month of the year at both Ellensburg and Cle Elum. The agriculture of the area consists of general farming and dairying. The preponderance of sunshine and long daylight greatly favor rapid growth of crops, and conditions are highly favorable for the production of hay, grain, peas, and potatoes and other root crops.

Thunderstorms and torrential rains are uncommon. Damaging hailstorms are rare. A large part of the precipitation comes as snow in winter and as slow rain in late fall and early spring. Strong westerly winds prevail throughout the spring and early summer, but high winds are uncommon during the rest of the year.

Tables 1 and 2, compiled from the records of the United States Weather Bureau stations at Ellensburg (record from 1892 to 1940) and Cle Elum (record from 1899 to 1940), give the important climatic data for the county.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Ellensburg, Kittitas County, Wash.*

[Elevation, 1,540 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year (1898)	Total for the wettest year (1937)	Average snowfall
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	28.2	59	−31	1.36	0.54	2.45	10.3
January	25.4	55	−29	1.35	.36	1.62	12.4
February	31.5	66	−20	.97	.47	1.40	6.2
Winter	28.4	66	−31	3.68	1.37	5.47	28.9
March	40.8	80	2	.53	.12	1.60	1.4
April	48.2	92	14	.34	.03	1.42	.5
May	55.4	98	25	.55	.12	.04	.0
Spring	48.1	98	2	1.42	.27	3.06	1.9
June	61.7	103	30	.61	.73	4.43	.0
July	68.2	110	30	.30	.05	.05	.0
August	66.8	103	29	.24	.29	.55	.0
Summer	65.6	110	29	1.15	1.07	5.03	.0
September	57.8	96	16	.57	.22	.35	.0
October	47.9	87	9	.58	.22	.39	(1)
November	36.4	70	−29	1.49	.56	3.14	4.8
Fall	47.4	96	−29	2.64	1.00	3.88	4.8
Year	47.4	110	−31	8.89	3.71	17.44	35.6

[1] Trace.

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Cle Elum, Kittitas County, Wash.*

[Elevation, 1,945 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year (1930)	Total for the wettest year (1899)	Average snowfall
	° F.	° F.	° F.	*Inches*	*Inches*	*Inches*	*Inches*
December	29.1	59	−27	4.07	0.41	4.12	23.9
January	26.7	54	−25	3.82	1.16	4.70	26.0
February	30.6	63	−21	2.62	1.66	7.04	17.3
Winter	28.8	63	−27	10.51	3.23	15.86	67.2
March	38.5	79	0	2.24	.19	5.86	7.4
April	44.9	88	15	1.07	.08	2.88	1.9
May	51.6	92	22	.98	.30	.28	.1
Spring	45.0	92	0	4.29	.57	9.02	9.4
June	57.9	99	25	.79	.02	1.03	.0
July	64.6	105	30	.36	.00	[1]	.0
August	63.9	102	23	.35	.00	1.13	.0
Summer	62.1	105	23	1.50	.02	2.16	.0
September	55.7	94	12	.94	[1]	.97	.0
October	47.1	86	10	1.76	.27	2.13	.6
November	33.8	72	−6	3.72	1.16	4.37	9.1
Fall	45.5	94	−6	6.42	1.43	7.47	9.7
Year	45.4	105	−27	22.72	5.25	34.51	86.3

[1] Trace.

Frost data for stations in and near Kittitas County are given in table 3.

TABLE 3.—*Frost data for stations in and near Kittitas County, Wash.*

Station	Length of record [1]	Average frost-free season			Longest frost-free season			
		Date of last killing frost	Date of first killing frost	Length of season	Year	Date of last killing frost	Date of first killing frost	Length of season
	Years			*Days*				*Days*
Trinidad, Grant County (near Vantage)	35	Apr. 5	Oct. 25	203	1934	Mar. 24	Nov. 24	245
Ellensburg	45	May 10	Sept. 29	142	1920	Apr. 23	Oct. 31	191
Cle Elum	42	May 30	Sept. 16	109	1940	May 13	Oct. 22	162
Lake Kachess	33	May 16	Oct. 3	140	1923	Apr. 9	Oct. 24	198

Station	Shortest frost-free season				Latest recorded date of killing frost	Earliest recorded date of killing frost
	Year	Date of last killing frost	Date of first killing frost	Length of season		
				Days		
Trinidad, Grant County (near Vantage)	1927	May 21	Oct. 31	163	May 21	Sept. 23
Ellensburg	1910	May 16	Aug. 24	100	June 14	Aug. 24
Cle Elum	1904	June 25	Aug. 24	60	June 28	Aug. 12
Lake Kachess	1910	May 16	Aug. 24	100	June 14	Aug. 24

[1] Including 1940.

AGRICULTURAL HISTORY AND STATISTICS

The early agriculture of Kittitas County was centered on the raising of livestock. The first settlers in the Kittitas Valley, in 1867, found good range lands for grazing herds of cattle. At that time an abundant growth of bunchgrass covered the arid uplands, and wild hay was cut for winter feed in the valleys. As farms were established along the stream bottoms, fields of grain and hay were irrigated by turning the water from the creeks into small ditches. Settlement and farming increased rapidly under the stimulus of ready markets furnished by mining camps in the mountains and by the growing towns on Puget Sound.

The need of adequate irrigation was early appreciated, and small community ditches were constructed to take water from the streams. The completion of the Northern Pacific Railway in 1886 and the opening of the coal mines at Roslyn further stimulated agriculture. Thereafter larger ditches were built to take water from the Yakima River. The Cascade Canal was completed in 1904, bringing the total area of irrigated land to more than 60,000 acres. Shipment of grain and hay to the Puget Sound markets became important.

As the valley lands were irrigated and farmed more intensively, range cattle were replaced by sheep, as the latter were better suited to grazing conditions on the depleted arid ranges and on the summer ranges in the mountain forests.

In recent years, the acreage of cropland has been greatly increased since the construction of the Highline Canal by the United States Bureau of Reclamation. This canal diverts water from the Yakima River at Easton and is designed to furnish irrigation water to about 70,000 acres of land. Of this, 35,000 acres is new land lying principally in the eastern part of the Kittitas Valley and the cut-over timbered area near Cle Elum and Easton. The remaining 35,000 acres consist of lands that were sometimes inadequately irrigated from the creeks. An uninterrupted flow of irrigation water has been delivered since 1932, and at present only 10 percent of the arable land under the Highline Canal remains undeveloped. This lies largely in the timbered area, where present farm prices do not justify clearing. The Federal census reported 35 percent more land from which crops were harvested in 1939 than in 1929.

At present the agriculture consists largely of the production of hay and grain and the raising of livestock. Dairying and potato growing are important, and apples are grown on a commercial scale in one small area. Peas are produced for seed, and garden vegetables and fruit are produced for home use.

CROPS

Table 4 gives the acreages of the principal crops, as reported by the census at 10-year intervals from 1899 to 1939.

TABLE 4.—*Acreages of principal crops in Kittitas County, Wash., in stated years*

Crop	1899	1909	1919	1929	1939
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
All wheat	8,574	4,099	16,378	13,764	8,864
Winter wheat				889	799
Spring wheat				12,875	8,065
All oats				7,321	11,147
For grain	2,041	5,437	4,660	6,837	10,907
Cut and fed unthreshed				484	240
Barley	2,888	766	2,031	3,149	3,357
Potatoes	618	1,331	771	1,829	7,198
Peas (dry)	64			42	304
All hay	27,864	44,539	48,979	34,750	49,676
Alfalfa	2,964	6,087	14,385	16,986	19,924
Timothy and clover, alone or mixed	[1] 2,589	27,628	13,619	12,879	18,597
Small grains for hay	6,583	3,251	3,189	2,111	2,266
Other tame hay	11,837	7,183	17,437	2,317	8,198
Wild hay	3,891	390	349	457	691
	Trees	*Trees*	*Trees*	*Trees*	*Trees*
Apples	[2] 32,723	38,244	71,105	[2] 92,136	[2] 16,534

[1] Clover alone.
[2] Apple trees are for the years 1900, 1930, and 1940, respectively.

The production of hay is the principal farming enterprise. Alfalfa, the most important hay crop, is grown throughout the irrigated lands and on all soils except the most shallow, poorly drained, or saline land. A small acreage is devoted to this crop without irrigation, on Swauk Prairie. Three cuttings are generally produced on the irrigated lands, and yields range from 1 to 6 tons an acre. Yields have declined on the older lands, owing to a number of causes, such as disease, weeds, high water table, and deficiency of phosphorus. Most of the alfalfa now grown is a mixture of Grimm, Cossack, and other varieties. New seed of better strains is needed. Northern-grown Common gives the best yields on deep well-drained soils, and Grimm, Cossack, or other varieties with spreading root systems are recommended for shallow soils.

Timothy and clover have been grown for hay since the early settlement and are still important crops, replacing alfalfa on the shallow and low-lying soils. They are generally grown together and are used locally for feeding livestock, although more red clover is being grown alone than formerly. Increased production of red clover is recommended on soils unsuited to alfalfa. Yields of timothy and clover range from 1 to 4 tons an acre.

Surplus hay is baled in the fields and shipped by rail or motortruck over the mountains to markets in the Puget Sound area. Clean alfalfa hay of the first and third cuttings is in demand; good clover hay or timothy-and-clover hay sells for 50 cents to $2 a ton less.

Much of the hay is fed on the farms or sold locally for winter feeding of cattle and sheep. This is considered good practice particularly the feeding of sheep in the fields.

Wheat has always been an important crop. The census reports 799 acres of winter wheat, producing 15,997 bushels, and 8,065 acres of spring wheat, producing 304,674 bushels, in 1939. On irrigated lands wheat is grown in rotation with hay or potatoes, and the yields commonly range from 40 to 80 bushels, although yields as high as 101 bushels to the acre have been reported. Wheat is the principal and often the only crop on the nonirrigated farms, where it is necessary

to summer-fallow the land every other year. Yields range from 10 to 20 bushels an acre in the Umtanum district on Manastash Ridge, from 20 to 40 bushels above the ditch in the Manastash district, from 10 to 15 bushels on Thorp Prairie, and from 15 to 30 bushels on Swauk Prairie.

More than 90 percent of the wheat is spring-sown, and Federation is the principal variety on both irrigated and nonirrigated land. Some Pacific Bluestem is also grown. Recently the drought-resistant and better yielding qualities of winter wheat are being recognized.

A small flour mill near Ellensburg and one at Thorp make flour and ground-feed products, principally for local consumption.

Oats are grown on practically all soils, largely on irrigated land. A large proportion of this crop is threshed for grain. Yields average about 60 bushels an acre on irrigated land, and yields of as much as 140 bushels are reported on the better soils. Victory is the principal variety grown. A production of 686,752 bushels was harvested from 10,907 acres in 1939.

Barley is grown to a small extent on practically all of the irrigated soils in rotation with hay and other crops. Most of the seed used is six-row barley of uncertain origin and variety. Beldi and Trebi are the varieties recommended. Yields range from 40 to 75 bushels an acre.

The production of potatoes has increased greatly during recent years. In 1939, 7,198 acres produced 2,079,578 bushels, which is almost four times the average and more than four times the production in 1929. Although potatoes return higher yields and are of better quality on well-drained soils of lighter texture, they are grown on a rather wide range of soils. Under irrigation the Russet Burbank (Netted Gem) variety is grown almost exclusively and yields from 5 to 20 tons an acre. In 1936, 1,074 tons of Netted Gem certified potatoes were produced. Both commercial and certified seed potatoes of the Irish Cobbler variety are grown on nonirrigated land, mainly on Swauk Prairie, where yields range from 1 to 2½ tons an acre. Further expansion of the potato acreage depends on market prices and the amount of injury from the flea beetle.

Peas are grown on 8,000 to 11,000 acres. Seed peas are principally of the Perfection variety and yield up to 75 bushels an acre. The prevalence of the nightshade weed is a serious handicap to the growing of peas in the Kittitas Valley.

In addition to the crops listed in table 4, sugar beets, reported for the first time in the census, were grown on 569 acres in 1939 and yielded 6,856 tons.

Commercial apple orchards are limited by the frost hazard to a small section known as the Edgemont district, which lies on the northward-sloping hills just east of the head of the canyon of the Yakima River on the south side of Kittitas Valley. Rome Beauty, Delicious, Jonathan, and Winesap are the varieties grown.

LIVESTOCK AND LIVESTOCK PRODUCTS

Sheep raising is the most important livestock enterprise in Kittitas County, although fewer sheep are raised now than formerly. The census reported 36,773 head of sheep over 6 months of age on April

1, 1940, as compared with 64,193 head in 1930. Bands of range sheep are brought into the valley from the mountains in the fall and are usually pastured in the hayfields and grainfields for some time before winter feeding is necessary. During mild winters some bands are grazed in the arid uplands, and feed is hauled out to them when needed. The ewes are commonly of Lincoln-Rambouillet cross-breeding, and the rams are Hampshire. Good market lambs are produced. Under normal conditions all the lambs are marketed in late summer or early fall, and the ewe bands are replaced by cross-breeds raised in eastern Oregon. There are a number of smaller farm flocks, mostly of the Hampshire breed. Range sheep raising is closely limited by available summer range, and the carrying capacity of the arid ranges has been lowered by overgrazing.

The number of cattle over 3 months of age on April 1 increased from 18,560 in 1930 to 27,156 in 1940.

Almost two-thirds of the cattle are beef cattle, raised mainly on the outlying ranches in the foothills and mountains. Hereford is the principal breed, and good purebred bulls are the rule. Some beef cattle are brought into the Kittitas Valley for winter feeding.

Dairying is a growing enterprise. In 1929, 5,533 cows were milked, producing 3,719,215 gallons of milk. By 1939 the number of cows milked increased to 9,440 and the production of milk increased to 5,582,453 gallons. Most of the milk is marketed in the form of butterfat, of which 1,480,925 pounds was sold in 1939, as compared with 991,585 gallons of whole milk sold. A large part of the butterfat produced is marketed cooperatively. There are several purebred dairy herds, and the production of milk per cow is increasing.

Most of the poultry is raised in small farm flocks, although there are several poultry farms. In 1939, 463,328 dozens of eggs were produced and 98,170 chickens were raised. The climate, feed, prices, and markets are favorable for expansion of poultry production. In 1939, 13,139 turkeys were raised. A cooperative egg and poultry association collects poultry products over a truck route through the county, providing for efficient marketing.

Horses have become more numerous as the number of farms has increased. There were 5,611 horses over 3 months of age on April 1, 1940, as compared with 3,706 on April 1, 1930. Few mules are kept; only 93 over 3 months of age were reported in 1940.

There were 4,755 hogs and pigs over 4 months of age on April 1, 1940, a substantial increase over the number reported in 1930, which was 2,326 over 3 months of age.

PRESENT AGRICULTURAL PRACTICES

Up to the present very little fertilizer other than barnyard manure has been used. General use of the legumes, particularly alfalfa, in crop rotations helps to maintain the nitrogen content of the soils. It has been found that all land that has been farmed for a long time is, in general, deficient in phosphorus, irrespective of the soil type. Experimental applications of superphosphate fertilizers have increased yields, especially when applied with nitrogen or potash. It is believed that a profitable increase in yields of alfalfa and of other crops would be obtained on the older land if phosphorus- and sulfur-containing commercial fertilizers were applied with barnyard manure.

Yields of potatoes have been increased greatly by applications of ammonium sulfate, which contains both nitrogen and sulfur, but as yet this fertilizer has been used on only a few farms. On the newer land the fertility of the soil is best maintained by the growing of legumes, applications of barnyard manure supplemented with phosphate, and the feeding of livestock in the fields. The use of commercial fertilizer is not profitable on new land, except for high-priced crops. On some of the shallow soils, crops show response to the application of phosphate fertilizers after the land has been in cultivation 2 or 3 years.

Fall plowing is the usual practice on the irrigated lands. The high winds in the spring dry the ground and blow the soil in the eastern part of the Kittitas Valley if it is worked too late in the spring.

The corrugation system of irrigation with small ditches about 3 feet apart is in general use, especially on the sloping land. Flooding is still practiced on the more nearly flat lands. Earth laterals and head ditches are used, as the cost of pipe lines and flumes is prohibitive except with intensive culture of special crops.

Most of the hay is stacked in the fields by buck rakes and overshot stackers. Hay land must be ditched after every cutting where the corrugation method of irrigation is used.

Grain is cut with a binder and threshed from the shock. The autumn season is usually dry until November, allowing ample time for harvest, although late-harvested potatoes are occasionally frozen in the ground and the third cutting of alfalfa is sometimes lost because of rainy weather.

On the nonirrigated wheat farms, plowing for summer fallow is done both in the fall and in the spring, depending on the season. For spring wheat the fallow is disked and seeded as early as possible. A large part of the grain is cut with binders and threshed from the shock.

Weed infestation has become a serious problem in the Kittitas Valley. Canada thistle, whitetop, morning-glory, sowthistle, and many other noxious weeds have become prevalent. Weed-control districts have been organized. A general practice is spraying, burning, and using other methods of controlling weeds along the roadsides and ditches, and, beginning in 1937, a program of weed eradication in the watersheds furnishing water for irrigation has been prosecuted with considerable vigor.

The supply of farm labor is usually adequate, though there is need for outside labor during harvesttime. This need is quickly filled by itinerant workers from various parts of the West. Except on the larger farms, livestock ranches, and dairy farms, a large part of the work is done by the farmers and their families.

FARM AREAS, TENURE, AND VALUE

The average size of the 1,196 farms in Kittitas County, as reported by the 1940 census, is 390 acres. It should be borne in mind that the average is greatly raised by the large acreages of the range and timberland holdings of a few outlying livestock ranches and dry-land grain farms. Most of the irrigated farms range in size from 20 acres to nearly a section, or 640 acres. The average size in the Kittitas Valley is less than 200 acres. Of the 83,555 acres from which crops were

harvested in 1939, 79,137 acres were irrigated; in addition 19,791 acres of pasture were irrigated.

Three-enterprise farms with a few side lines have proved most efficient and profitable. The types of farming most common in the irrigation area are (1) hay, grain, and dairying, and (2) hay, grain, and potatoes.

On the older and well-established farms the dwellings are commodious and well built and the other farm buildings are adequate and usually kept in good repair. On the new lands some farms have adequate buildings, but many are of temporary character.

Farm tenancy in 1940 was 25.4 percent, an increase of 3.2 percent over that reported in 1930. Most of the farm tenants pay rentals in crops.

Table 5 gives farm areas, value, and tenure in the census years from 1890 to 1940.

TABLE 5.—*Farm areas, value, and tenure in Kittitas County, Wash., in stated years*

Year	Farms		Land in farms		Improved land		Average value of all property	Farms operated by—		
	Number	Average size	Total area	Proportion of area of county	Total area	Proportion of farm land		Owners	Tenants	Managers
		Acres	*Acres*	*Percent*	*Acres*	*Percent*		*Percent*	*Percent*	*Percent*
1900	699	284.8	199,085	13.4	55,057	27.7	$4,558	84.0	14.9	1.1
1910	871	301.5	262,607	17.6	75,939	30.1	16,638	77.7	18.1	4.2
1920	928	232.7	215,918	14.5	95,984	44.5	20,412	75.5	22.8	1.7
1930	888	404.3	359,003	24.1	95,014	23.7	19,854	75.5	22.2	2.3
1940	1,196	390 0	466,401	31.5	108,216	23.2	[1] 10,857	73.7	25.4	.9

[1] Includes value of land, buildings, and implements but excludes value of livestock. Comparable value in 1930 was $17,323.

Land values decreased greatly between 1920 and 1940, following the depression and retrenchment. The average value of land and buildings, as reported by the Federal census, fell from $73.52 to $24.59 an acre. At present the most valuable land in the Kittitas Valley lies under the older and cheaper irrigation ditches, where the annual cost of water is about $1 an acre. Land composed of the better soils with good improvements commands the highest prices. New land with only moderate improvements under the Highline Canal, with a water cost of $2.50 an acre in 1937 and a construction charge based on 5 percent of gross crop income, sells for considerably less. Poorly drained land and land affected by toxic accumulations of salts is held at very low prices. The price of unimproved or partly improved cut-over land in the timbered district depends on soil, relief, value of remaining timber, and ease of clearing. Nonirrigated wheatland has a low value and semiarid range land a still lower, depending on the location and grazing value.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of soil

layers or horizons, called collectively the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail, and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [3] and its content of lime, or calcium carbonate, and "alkali" are determined by simple tests.[4] The drainage, both internal and external, and other external features, such as stoniness and the relief or lay of the land, are taken into consideration, and the interrelation of the soil and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, with special emphasis upon the features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into classification units, the three principal of which are (1) series, (2) type, and (3) phase. Areas of land, such as scabland or bare rocky mountainsides, that have no true soil, are called (4) miscellaneous land types.

The most important of these groups is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from one type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Taneum, Manastash, and Simcoe are names of important soil series in Kittitas County.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Manastash loam and Manastash fine sandy loam are soil types within the Manastash series. Except for the texture of the surface soil, these types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type differing from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion are frequently shown as phases. For example, within the normal range in relief of certain soil types, some areas are adapted to the use of machinery and the growth of cultivated crops, and others are not. Even though no important differences exist in

[3] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity, and lower values, acidity.

[4] The term "alkali" is used in this report in its popular or agricultural sense and refers to toxic accumulations of mineral salts in soils or water. These salts are generally neutral in reaction and are known as "white alkali" but may include true alkali salts, of which sodium carbonate or "black alkali" is most common. The total content of readily soluble salts is determined by the use of the electrolytic bridge. Lime is detected by application of dilute hydrochloric acid. Phenolphthalein solution is used to detect the strong alkaline reaction associated with black alkali.

the soil itself or in its capability for the growth of native vegetation throughout the range in relief, important differences are observed in the growth of cultivated crops. The more sloping parts of such soil types are segregated on the map as a sloping or a hilly phase. Similarly, some soils with many stones are mapped as stony phases, even though differences in stoniness are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county showing the location of each of the soil types, phases, complexes, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS [5]

Kittitas County lies in a region of striking contrasts in climatic conditions, vegetation, physiographic features, and agriculture. In a 2-hour drive from Vantage on the Columbia River to Snoqualmie Pass, one may observe as wide a range in conditions as in a trip across several Eastern or Midwestern States. The soils are correspondingly varied, and their pattern of distribution is complex. As there are several climatic zones, no one soil is dominant or characteristic of the county, nor do the large number of different soils fall readily into groups according to land use. The agriculture is determined largely by and is adjusted to the climatic conditions, relief, supply of water for irrigation, and markets, rather than to differences in soil.

In general, the important crops of the county are grown on all the soils where conditions of climate, drainage, and supply of water for irrigation are favorable or not too adverse. Well-drained soils of medium light texture, however, are preferred for alfalfa and potatoes. Commercial apple orchards are confined largely to the Renslow soil of the north-sloping hills just east of the head of the canyon of the Yakima River, in the Edgemont district. Where there is sufficient precipitation, tillable soils lying above irrigation are devoted to dry-land grain farming, irrespective of the kind of soil.

For purposes of discussion the soils of Kittitas County are placed in the following groups: (1) Soils of the semiarid uplands and terraces; (2) soils of the semiarid lowlands and stream bottoms; (3) soils of the humid and subhumid uplands and stream valleys; (4) organic soils; and (5) miscellaneous soils and land types.

The soils of the semiarid areas include all the treeless land east of the head of Kittitas Valley. They include soils having a wide range in color, texture, topography, and profile character, but all have the characteristics common to soils formed under an arid or semiarid climate. The surface soil layers are relatively unleached; that is, they have not been impoverished of soluble mineral plant nutrients by downward movement of moisture through the soil. The

[5] A small part of this area in the northeast joins with a much earlier soil survey: MANGUM, A. W., VAN DUYNE, CORNELIUS, and WESTOVER, H. L. SOIL SURVEY OF THE QUINCY AREA, WASHINGTON. U. S. Bur. Soils Field Oper. 1911: 2227–2286, illus. 1914.
Owing to the greater detail of the soil survey of Kittitas County and to accumulation of data and development in soil classification in this region since the date of the earlier survey, a few minor conflicts in classification and mapping appear in a comparison of the two areas. These include small areas of the Yakima soils of the later survey that join with the Beverly soils of the earlier survey. These two series of soils are similar, and in the small area included in the later survey they were thought to be more closely related to the Yakima soils. Small areas of the Cohasset and Quincy soils of the earlier survey join with scabland in the later one, in which these nonagricultural areas are mapped in greater detail.

dominant color of the surface soil is light grayish brown. Wherever there is sufficient moisture to support abundant grass growth, organic matter accumulates in the surface layers, and the soil is dark grayish brown or in some places nearly black. All the older soils have clay horizons developed in the subsoil.

These soils are inherently fertile and productive under irrigation. The lighter colored members are low in organic matter and nitrogen, but this deficiency is not a serious handicap in an irrigated area where alfalfa and other legumes, which supply nitrogen, are commonly grown in rotation. Even the shallow and gravelly soils produce profitable crops where properly tilled and irrigated.

The soils of the semiarid areas are placed in two major groups according to physiographic position: (1) Soils of the semiarid uplands and terraces and (2) soils of the semiarid lowlands and stream bottoms. In places, however, soils of these two positions merge without distinct demarcation. These have, in turn, been placed into subgroups based on surface and internal drainage.

Soils of the humid and subhumid uplands and stream valleys are also placed in subgroups, the bases being drainage and vegetation.

In the following pages the soils of Kittitas County are described and their agricultural importance is discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in table 6.

TABLE 6.—*Acreage and proportionate extent of the soils mapped in Kittitas County, Wash.*

DETAILED SURVEY

Type of soil	Acres	Percent	Type of soil	Acres	Percent
Renslow loam	6,656	0.5	Teanaway loam, terrace phase	1,600	0.1
Selah loam	17,024	1.2	Cle Elum fine sandy loam	6,528	.4
Selah loam, terrace phase	2,304	.2	Cle Elum loam	1,088	.1
Manastash loam	6,592	.4	Pond Oreille loam	4,992	.3
Manastash fine sandy loam	256	(1)	Volperie loam	384	(1)
Reeser loam	2,304	.2	Volperie loam, terrace phase	448	(1)
Taneum clay loam	3,456	.2	Bertolotti fine sandy loam	1,664	.1
Taneum clay loam, eroded phase	832	.1	Bertolotti loam	832	.1
Taneum silty clay loam	1,152	.1	Roslyn fine sandy loam	4,288	.3
Simcoe clay	1,536	.1	Springdale gravelly sandy loam	3,776	.3
Simcoe stony clay	640	(1)	Volke sandy clay loam	320	(1)
Waha clay	128	(1)	Quicksell loam	960	.1
Onyx loam	3,072	.2	Swauk loam	5,312	.4
Onyx fine sandy loam	576	(1)	Garrison fine sandy loam	448	(1)
Yakima loam	7,872	.5	Latah clay loam	320	(1)
Yakima fine sandy loam	4,608	.3	Peoh loam	320	(1)
Yakima very gravelly sandy loam	7,232	.5	Peoh clay	768	.1
Naches fine sandy loam	11,776	.8	Peoh silty clay loam	704	(1)
Naches clay loam	8,064	.6	Peat	256	(1)
Esquatzel very fine sandy loam	1,984	.1	Stony and shallow soils	35,776	2.4
Kittitas silt loam	3,264	.2	Stony and shallow soils (timbered)	4,992	.3
Ahtanum loam	4,800	.3	Riverwash	14,016	1.0
Woldale clay loam	9,600	.7	Steep broken land	48,576	3.3
Woldale clay	384	(1)	Rough mountainous land	30,080	2.0
Nanum loam	9,216	.6	Scabland	27,136	1.8
Wenas loam	8,128	.6			
Wenas gravelly loam	2,368	.2	Total	328,960	22.2
Teanaway loam	7,552	.5			

RECONNAISSANCE SURVEY

Rough mountainous land	723,904	48.9	Renslow-Selah loams	25,408	1.7
Rough broken land and scabland	309,280	21.9	Valley land, undifferentiated	34,048	2.3
			Total	1,152,640	77.8
			Total of county	1,481,600	100.0

1 Less than 0.1 percent.

SOILS OF THE SEMIARID UPLANDS AND TERRACES

Owing to relief, the soils of the semiarid uplands and terraces have under natural conditions adequate to excessive surface drainage, except in a few included small flat areas or in small areas along drainageways. Internal drainage, however, is retarded in some of the soils, and under irrigation areas have become affected by accumulated waters from seepage and surface drainage waters, so that artificial drainage has become a desirable practice.

The soils of the semiarid uplands and terraces underlain by permeable subsoils and substrata giving free subdrainage are represented by the Renslow soil; those underlain by less permeable or relatively impermeable subsoils and substrata include the soils of the Selah, Manastash, Reeser, Taneum, Simcoe, and Waha series.

SOILS WITH FREE SUBDRAINAGE

Renslow loam.—Renslow loam, an adaptable and valuable soil, is developed on deposits of loess, or wind-laid material, which commonly occur on north and east slopes. Of all the soils it most nearly represents the zonal or climatic soil of the more arid part of the county. In the virgin condition the surface layer of Renslow loam to a depth of 2 or 3 inches is grayish-brown loam containing some grains of coarse sand formed of basalt particles. It is not compact and is structureless. Beneath this material and continuing to a depth of about 14 inches is dull-brown moderately compact smooth loam with widely spaced vertical cracks. This breaks into large soft blocks, which, in turn, crush easily into a single-grain mass containing some irregular friable clods. The subsurface layer is brown loam similar to the overlying material but slightly lighter in color. The subsoil, lying between depths of about 24 and 36 inches, is smooth compact loam that is somewhat lighter brown than the material above and breaks into irregular clods and chunks. This is underlain to a depth of about 52 inches by light grayish-brown heavy, compact loam, that breaks into hard clods of varying size and which is quite friable considering the degree of compaction. The layer below this is light grayish-brown loam that is soft and very slightly compact. In this layer there is a slight or moderate accumulation of lime; the material effervesces with dilute acid. At a depth of about 58 inches this layer rests on similar material, a smooth mixture of very fine sand and silt, which is the loess or wind-borne material on which the soil is developed. The blanket of loess varies greatly in thickness. It overlies several different materials, commonly basalt at higher elevation; basin-filling rubble; sandstones and shales of the Ellensburg formation at lower levels; or older soils.

A variation, included with this soil on the map, occurs in several small bodies in the vicinity of Fairview School in T. 18 N., Rs. 19 and 20 E. This soil is of slightly coarser texture than typical Renslow loam and is underlain by coarse valley-filling material at a depth of 2 to 4 feet. Here the lime accumulation is much more pronounced than in the typical soil.

Although irrigated areas of Renslow loam are small and scattered, the soil is widely distributed in protected places. In the Kittitas Valley it occurs mainly along the slopes of the eastern margin in the Edgemont district and in Badger Pocket. An irregular body, several square

miles in extent, lies on the smooth top of Manastash Ridge southeast of Ellensburg. Renslow loam also covers a large part of the semiarid uplands shown on the reconnaissance map in the Squaw Creek basin and occurs elsewhere in the eastern part of the county as Renslow-Selah loams.

More than 6,000 acres of this soil is under irrigation in the Kittitas Valley, and about 2,500 acres on the Manastash Ridge is devoted to dryland grain farming. The rest lies above irrigation, is too dry for the production of crops, and is used only for grazing.

The relief of Renslow loam comprises gently sloping or undulating to steep hill slopes. The areas of this soil are commonly broken and dissected by coulees that head on the higher ridges and traverse the sloping margins of the basins. The soil is exceedingly variable in depth; it commonly thins out where it borders areas of rough broken land and scabland on the eroded slopes of the ridges, and it also thins out above older soils along the lower margins in the basins.

Renslow loam is especially well suited to the production of alfalfa, potatoes, and tree fruits, and it is also well suited to the production of grains where the available nitrogen supply is kept up by proper rotation with alfalfa and other legumes. The deep medium-textured soil favors proper tillage and the absorption and retention of irrigation water. There is no seepage or accumulation of alkali except in small local spots just below large irrigation ditches. As the soil erodes easily, very careful irrigation is necessary to prevent washing, especially on steeper slopes.

Alfalfa yields from 3 to 6 tons and potatoes from 250 to 650 bushels to the acre. Good grain crops are produced in rotations with legumes.

Orchardists of central Washington recognize the superior value of Renslow loam and similar deep loessial soils for heavy yields and fine quality of apples and other tree fruits. Most of the commercial apple orchards of the Edgemont district are on this soil.

SOILS WITH IMPAIRED SUBDRAINAGE

Selah loam. Most of this soil has been in cultivation only since the construction of the Highline Canal in 1932. Where a foot or more of the surface soil remains, the land produces good crops of clover, grain, or peas, but it is not adapted to row crops because of erodibility. In undisturbed typical areas the surface layer, to a depth of about 4 inches, is light grayish-brown loam. Beneath a thin desert mulch the material is slightly compact and laminated or platy, breaking up into fine, soft granules. A dull-brown smooth-textured loam lies between depths of 4 and 11 inches. This material contains large moderately compact prisms breaking horizontally into soft blocks, which, in turn, are easily crushed into single grains. Below this a layer of brown gritty clay or clay loam extends to a depth of 18 inches. The material in this layer is compact and contains hard, rough prisms that break into small irregular clods. It is underlain to a depth of about 29 inches by rich-brown very heavy dense colloidal clay having a pronounced vertical structure and forming large prisms that break into smaller prisms. This is underlain to a depth of 33 inches by a light-gray soft layer of accumulated lime stained with brown. Below this a layer of nearly white hard limestonelike caliche (pl. 3, *A*) extends to an

average depth of about 45 inches. The caliche occurs in large broken slabs. It rests on cemented gravel beds, which extend to an unknown depth. The surface and subsurface layers are leached of lime.

Although the above-described profile represents the undisturbed soil where typically developed, in many places on slopes the surface soil has been removed by erosion and the heavy clay now lies within a few inches of the surface. In small spots on steep slopes of coulees it is exposed. Some gravelly patches are included in mapping, and a few stones are present in the surface soil.

About 2,000 acres in the extreme eastern parts of The Park district and Badger Pocket are not quite typical of Selah loam, but are included with it in mapping. This included soil is lighter gray and is slightly coarser than the typical soil. The original surface soil has been disturbed by winds to some extent, and in some places the surface soil is calcareous from small included particles of caliche. This variation probably represents a transition to the Burke soils mapped in earlier surveys in Benton County and in other areas east of the Columbia River.

Another variation is represented by a body of approximately 400 acres about 1 mile north of Badger Pocket School. In this area the original Selah soil has been disturbed by floodwaters from the large coulee called Wipple Creek. The caliche has been washed out in places and replaced by outwash rubble. Some coarse angular gravel of basaltic origin is scattered through the surface soil.

There are also some areas of Selah loam having a thinner subsoil in the eastern end of Kittitas Valley, where about 6,000 acres are under irrigation. Certain areas are too arid for farming and are used only for the scant grazing afforded by the vegetation dominated by sagebrush (pl. 3, *B*).

The typical areas of Selah loam are mainly in The Park district, where the soil reaches its most pronounced development and is best preserved from mutilation. The total area mapped is 17,024 acres, most of which is irrigated by the Highline Canal.

The relief of Selah loam ranges from gently sloping and undulating to moderately hilly. Surface drainage is generally adequate or excessive except in small scattered areas. Underdrainage varies according to the character and thickness of the subsoil and the substratum. Seepage and alkali accumulations occur only in flat or low places subject to seepage from irrigation ditches.

Only the bodies of deeper soil are well suited to potatoes. Alfalfa has returned good yields thus far, but it is probable that some difficulty will be experienced in maintaining a good stand because of the heavy-textured subsoil. Careful irrigation is necessary because the movement of water is retarded by the relatively impervious subsoil and substratum, which easily become saturated. The surface soil erodes severely on slopes when the land is devoted to row crops. Clover for hay or mixed grasses and clover for permanent pasture are recommended for the areas of shallow soil and for all the sloping areas. Uneven distribution of irrigation water in the soil in such places is reflected in differences in the growth of plants and in the time the crops mature.

The low content of organic matter and nitrogen in the virgin soil is not a serious handicap if legumes are commonly grown in rotation.

The acreage of the different crops varies greatly from year to year because much of the land has been settled and brought under irrigation only recently. It has been necessary for the new settlers to grow a high proportion of cash crops, but more of the land is being put into alfalfa, clover, and other forage crops. A large acreage was planted to peas for seed during the season of 1936.

There are few apple orchards on this soil in the Edgemont district, and in Yakima County large acreages of it have been devoted to apples and other tree fruits for many years. In Kittitas County this soil has produced fair to good yields of fruit that has a good color, but the growth of trees is uneven, owing to the variation of the depth of the surface soil, the thickness of the heavy subsoil layer, and the retarded underdrainage. A few trees have become diseased and have died because of waterlogged soil around the roots.

Loss of the surface soil by erosion during high winds in the spring and during irrigation is a serious problem. This is particularly true on the more sloping tracts of new land planted to row crops, peas, and grain, which do not form a sod. Under general farming in newly settled areas the cost of pipe lines or flumes for distributing water is usually prohibitive, necessitating the use of earth head ditches and long runs. This is another reason for keeping as much as possible of the sloping land in alfalfa or other permanent hay crops.

Selah loam, terrace phase.—This soil differs from typical Selah loam in having a smoother surface, more uniform depth, and more uniform development. The clay subsoil is from 4 to 8 inches thick and lies below a uniform brown loam surface layer and subsurface layer at a depth of ½ to 2½ feet.

This phase occupies a small area on a low, undulating, terracelike bench 2 miles south of the town of Kittitas. This land is irrigated from the Town and Cascade Canals and is well farmed. Hay, grain, and potatoes, the principal crops, return moderate to good yields. Drainage is generally adequate, but owing to the slow underdrainage, careful irrigation must be practiced to avoid waterlogging the surface soil.

Manastash loam.—The gently sloping or nearly flat surface of Manastash loam is favorable for tillage and the distribution of irrigation water. Because of slow underdrainage, however, irrigations should be light and frequent and shallow surface drains should be provided to carry off the surplus water, if farming operations are to be successful.

Manastash loam has a surface layer, about 3 inches thick, of medium dark dull-brown loose and finely granular loam. This is underlain by medium dark dull-brown gritty loam or heavy loam that is compact but friable and breaks readily into hard, coarse granules. Between depths of about 8 and 17 inches there is a subsurface layer of compact gritty heavy loam similar in color to the overlying material. This layer breaks out in large blocks that are friable and easily crushed. The subsoil of light olive-brown plastic clay reaches to a depth of 36 inches. This material is very tenacious when wet and hard and compact when dry. It is roughly prismatic in structure, breaking into hard, sharp clods. This layer rests on beds of impervious cemented gravel many feet thick.

The entire soil is noncalcareous, except for a slight sporadic development of accumulated lime in its easternmost areas, where it is transitional in character and somewhat similar to the Selah soils.

In few places Manastash loam is more than 3 feet thick over the cemented gravel. This is particularly true on the north side of the Yakima River in the Reeser Creek district on the Kittitas Valley. Underdrainage is arrested in the typical soil, and in the flat areas the soil sometimes becomes waterlogged from irrigation on the adjacent slopes.

A deeper variation of Manastash loam, which has a higher agricultural value, is included with the typical soil on the map. This variation covers about 900 acres, principally in the Manastash district. One large body begins ½ mile west of Cove School and extends 2½ miles northeastward, nearly to the north line of sec. 31, T. 18 N., R. 18 E. A few smaller bodies lie east of this, and another is north of Woldale in sec. 21, T. 18 N., R. 18 E. This included soil ranges from 3 to 5 feet in thickness over the cemented gravel, and in places the clay subsoil is absent. Drainage conditions are more favorable in this variation than in the typical soil.

Manastash loam occupies 6,592 acres in Kittitas Valley. All the land is irrigated except a number of small bodies lying above the Highline Canal in the Reeser Creek district.

Most of this soil is used for grain, alfalfa, and other hay crops. Some potatoes are grown. Yields of 2 to 5 tons of alfalfa are obtained, but good stands are difficult to maintain where the soil is thin and underdrainage is retarded. Such varieties of alfalfa as Grimm and Cossack, having spreading root systems, are best adapted. Red clover and grass hay crops are better adapted to this soil than alfalfa. The deeper soil variation, however, is well suited to all the common crops.

Manastash fine sandy loam.—In contrast with Manastash loam, Manastash fine sandy loam is well drained. All this soil is farmed and irrigated.

The 2-inch surface layer of Manastash fine sandy loam consists of brown loose fine sandy loam. This overlies a 16-inch layer of brown slightly compact massive finely granular fine sandy loam containing some embedded pebbles. Below this is a darker rich brown layer about 12 inches thick consisting of moderately compact massive friable loam containing some pebbles and gravel. The upper subsoil layer, which lies between depths of about 30 and 36 inches, is rich-brown sandy clay loam that is compact and massive but friable. This is underlain to a depth of 52 inches by rich-brown heavy, compact sandy but somewhat friable clay containing some embedded pebbles. This material overlies cemented gravel.

This soil occurs on the outer margins of high terraces south and northwest of Thorp. Although the surface is nearly level, drainage is good because the soil is comparatively deep and coarse-textured and lies near escarpments. It is well suited to all general farm crops, especially alfalfa and potatoes. Only 256 acres are mapped, but all the land is under irrigation and is highly developed.

Reeser loam.—Reeser loam is similar to Manastash loam in many profile features but has a darker colored surface soil and upper

subsoil layer and generally is slightly heavier in texture. In the virgin condition the surface layer, about 1½ inches thick, consists of dark-gray laminated and finely granular silty loam, underlain by a 6-inch layer of dull dark-gray moderately compact loam that breaks out in friable, finely granular aggregates. Below this is a subsurface layer of similar colored heavy silt loam or silty clay loam breaking into friable coarse granules and clods when dry. This material continues to a depth of 18 inches. The upper subsoil layer, which is about 5 inches thick, consists of gray silty clay containing small prisms that are hard and resistant when dry. The lower subsoil layer lies between depths of 22 and 36 inches and consists of light greenish-olive very heavy tenacious clay having small white flecks and streaks of lime. This material overlies firmly cemented beds of gravel and cobblestones.

As mapped, this soil includes a number of small variations. The color of the surface soil ranges from dark grayish brown to black, and the depth to cemented gravel is variable. Small patches of very similar shallow soil strewn with surface gravel and cobbles are common in marginal areas adjoining the areas of stony and shallow soils with which this soil is intimately associated.

Reeser loam occurs in the northwestern part of the Kittitas Valley, principally on the gentle south slopes in small strips and depressions in association with Manastash loam. The total area is 2,304 acres. The land above the Highline Canal in this vicinity is partly irrigated by small ditches from Green Canyon and Reeser Creek.

The moderately sloping northernmost areas of this soil have adequate surface drainage, and hay and grain crops can be grown where there is sufficient irrigation water. Reeser loam is a fertile soil and produces good crops of grain, particularly oats. The nearly flat depressions, however, are commonly limited by poor drainage to grass hay, red clover, and pasture.

Taneum clay loam.—This is a fertile, productive soil, generally well drained and suited to the growth of all common crops of the Kittitas Valley.

The 2-inch surface layer consists of dark-brown loose and granular heavy clay loam, over a 4-inch layer of dark-brown compact clay loam that breaks into large friable granular clods. The subsurface layer, which is 12 inches thick, is dark-brown compact clay loam or silty clay loam, breaking into large friable blocks and clods. At a depth of 16 to 18 inches this rests on the upper subsoil layer of medium-brown silty clay loam that is massive and compact but friable. The lower subsoil layer, lying between depths of 36 and 46 inches, is medium-brown clay. This material is roughly prismatic and breaks into sharp fragments and coarse granules. Below this, the parent material is light brown massive and vesicular sandy clay, which grades with increasing depth into decomposing tuffaceous sandstone.

This soil is developed upon beds of sandy clay derived by weathering of tuffaceous sandstones of the Ellensburg formation. It occurs on the foot of the hills around the southwestern and western margins of the Kittitas Valley.

The dark color has been developed by an abundant cover of grass supported by higher precipitation on the foothill slopes. The relief ranges from gently undulating to moderately hilly, and in a few

places the hill slopes are steep. The soil areas border rough broken land and stony and shallow soils along the more elevated margin and commonly join the Manastash soils on the valley side. Several isolated areas occur farther out in the valley on both sides of the river northwest and east of Thorp.

Under irrigation this soil is largely used for alfalfa and grain. In all it occupies 3,456 acres. About 500 acres lie above the South Branch Canal and are used for dry-land wheat farming. Yields range from 15 to 40 bushels an acre, depending largely on seasonal precipitation.

Taneum clay loam, eroded phase.—This phase comprises areas of Taneum clay loam that have a very thin surface soil owing to geologic erosion or to lack of favorable moisture conditions and a consequent sparse cover of vegetation. In exposed situations where erosion has been especially severe, the clay subsoil, or in places even the clay parent material, is exposed.

Only 832 acres of this soil, in small widely scattered areas in the western part of the Kittitas Valley, are mapped.

Growth of plants on this soil varies with the depth of the remaining surface soil. Grain generally returns profitable yields for several years on new land. As alfalfa does not do well, the deficiency in organic matter and nitrogen can best be built up and maintained by growing clover, sweetclover, or peas, preferably to be plowed under as green manure, in rotation with grain. Permanent pasture of clover and mixed grasses is recommended. On the moderate or steep slopes it is difficult to get good penetration of irrigation water and to prevent washing.

Taneum silty clay loam.—The surface layer of Taneum silty clay loam, which is about 5 inches thick, consists of dull dark grayish-brown silty clay loam that is loosely laminated and granulated in the upper 2 inches and laminated or platy and friable below. This is underlain to a depth of 20 inches by a subsurface layer of dull dark grayish-brown clay or silty clay. The material in this layer is compact, roughly prismatic in structure, and friable, and when disturbed it breaks into small nut-sized fragments and coarse platy granules. The subsoil is about 16 inches thick and is dull dark olive-brown heavy clay having a small prismatic structure that breaks into small sharp fragments. The upper part of the underlying parent material, reaching to a depth of 60 inches, is light olive-brown massive and vesicular heavy clay. It grades below into decomposing tuffaceous sandstone.

This soil occurs mainly in one large body on the terracelike bench west of Thorp and occupies a total area of 1,152 acres.

Most of the land is gently sloping or nearly flat, but several small areas on moderately steep hillsides are included. Taneum silty clay loam is a fertile, productive soil particularly well adapted to grain. Although underdrainage is slow, surface drainage is generally adequate. The soil is used largely for grain and alfalfa, which return high yields.

Simcoe clay.—In typical areas, the surface layer of Simcoe clay consists of medium to dark grayish-brown, loose, finely granular clay from 4 to 7 inches thick. The subsurface layer, which is about 10 inches thick, consists of dark-brown compact laminated or platy clay.

The upper subsoil layer is dark-brown gritty clay that is compact and somewhat vesicular with a platy or blocky structure. It reaches to a depth of 20 to 40 inches. Below this is the lower subsoil layer of medium-brown clay. The material in this layer is very compact and hard and has a prismatic structure. At a depth of about 30 to 60 inches it grades into gritty clay filled with angular fragments of basalt.

Most of the areas of this soil border the Kittitas Valley and Swauk Prairie. As occurring in this county, the surface soil of Simcoe clay varies in color and texture. Patches having a coarse-textured brown loam surface layer, ranging from 2 to 12 or more inches in thickness, are common. In the bodies on Swauk Prairie and north of the Teanaway River the soil is developed on the Teanaway basalt, which is older than the Yakima basalt of the eastern end of the county. Here the surface soil ranges from medium brown to nearly black, and the clay subsoil is much thicker, owing to a deeper weathering of the basalt, and has a purple hue. Generally, no lime has accumulated, although in some places the underlying fragmental basalt is coated with lime.

About 300 acres of Simcoe clay is irrigated by small ditches from Nanum Creek and is devoted to grain and hay; the rest is used for dry-land grain farming and grazing. The total area of this soil is 1,536 acres.

Underdrainage is impaired by the impervious character of the clay subsoil. In most places surface drainage is adequate or excessive. Simcoe clay is best suited to grain, hay, and irrigated pasture. Alfalfa grows with fair success, but red clover does better.

Simcoe stony clay. Simcoe stony clay is of variable character and ranges from 1 to 2½ feet in depth. Basalt boulders and cobbles are commonly scattered over the surface and through the surface soil. Only 640 acres are mapped, all in the upper Nanum and Reeser Creek districts. About 300 acres, which are under irrigation, have been cleared of surface stone, and are used for grain and hay. Small areas of this soil are included with rough broken land and with scabland on the reconnaissance map.

Waha clay.—Waha clay is a fertile soil but is inextensively developed in this county. Only 128 acres are mapped in a few areas in the upper Nanum Creek district.

The surface soil of Waha clay consists of a 4-inch layer of dark grayish-brown friable and granular clay, underlain by a layer, about 8 inches thick, of dark grayish-brown compact clay that breaks into clods. The upper subsoil layer, lying between depths of about 12 and 24 inches, is dark grayish-brown compact clay. This material has a roughly prismatic structure and breaks into rough somewhat friable coarsely granular clods. The next lower layer, about 6 inches thick, consists of dull olive-brown very heavy dense clay forming small prisms. These prisms break into sharp fragments that are heavily coated with white. The upper part of the parent material to a depth of more than 50 inches is light olive-yellow sandy clay, breaking into sharp fragments when dry. It is derived from the weathering of basaltic rocks.

Waha clay occupies nearly flat areas where surface drainage is retarded and rather moist conditions prevail. It is a strong soil, well

suited to grass hay, red clover, and grain, particularly oats. Drainage, however, in many places is inadequate. All the land is under irrigation and is devoted to the production of grain and hay.

As mapped in this county, this soil is not typical of the Waha soils mapped in other areas. It occupies more nearly level land and is not so well drained as the typical soil.

SOILS OF THE SEMIARID LOWLANDS AND STREAM BOTTOMS

Developed on the semiarid lowlands and stream bottoms are a number of widely different soils having the ground water table at comparatively slight depths. Although these soils occur at different levels and have a variable degree of slope, they lie in the path of movement of underground water supplied by streams or by seepage from irrigation on the higher lands. For the most part they are sufficiently well drained to produce crops, but all receive some seepage from adjacent land, which creates drainage problems now or may do so in the future.

On the basis of surface drainage and character of subsoil and substrata that facilitate or hamper effective underdrainage, these soils are grouped as (1) well-drained soils, (2) well-drained soils with imperfectly drained inclusions, and (3) imperfectly drained soils.

WELL-DRAINED SOILS

The subgroup of well-drained soils includes members of the Onyx series, which consist of recent alluvial-fan materials, and members of the Yakima series, which consist of recent alluvial soils of the major stream bottoms.

In these soils the subsoils and underlying materials are sufficiently porous to allow free percolation and lateral movement of underground water, by means of which excess subsurface waters readily find their way into natural or artificial drainage channels. Improvement of these soils by means of drains is therefore much more readily and cheaply effected than in the soils having less permeable underlying materials.

Although both the Onyx and the Yakima soils typically occur in the areas of low rainfall and desert shrub and grass vegetation, they are not confined to the semiarid valley but extend well up the valleys of the larger streams, where they support a vegetation of cottonwood, pine, and brush. Most of the soil materials have been carried by water from the higher, more humid parts of the county and are richer in organic matter and lower in content of bases than are most of the other soils of the semiarid belt. Inclusion of these soils with the soils of the semiarid areas is therefore to be accepted with reservations.

Onyx loam.—Onyx loam is productive, and all the commonly grown crops produce high yields. The soil is particularly well suited to alfalfa and potatoes, except in the gravelly areas.

The more typical surface soil of Onyx loam consists of brown slightly compact structureless loam 6 to 12 inches thick. The underlying soil to a depth of 36 or more inches is brown or light-brown moderately compact loam that breaks into friable clods. Some of the soil materials have been eroded from adjacent areas of loessial soils, but a larger part has come from the foothills or higher ridges.

The soil carries a considerable contribution of material weathered from basic igneous rocks under a higher rainfall than that of the basin lands where the soil now lies.

Onyx loam varies greatly in depth because of differences in the deposition of the soil material. In some places it has been deposited over outwash gravel; in other places it has been deposited over older soils.

A total of about 180 acres, occurring in three bodies south and southeast of Dammon School in secs. 15 and 23, T. 17 N., R. 18 E., has a heavy clay underlying typical Onyx loam at a depth of 3 to 5 feet. Here underdrainage is somewhat impaired, but for convenience these areas are included with typical Onyx loam in mapping.

A number of small gravelly alluvial fans, widely scattered near the margin of the basin of Kittitas Valley, are also included. The bodies of this gravelly variation, which lie below the foothill slopes of the Manastash Ridge, are darker and heavier textured than typical Onyx loam.

A third inclusion represents several small alluvial fan areas of a darker colored soil along Swauk Creek, just west of Ballard School, near the Teanaway River, and west of Nelson.

As mapped along the Columbia River south of Vantage, Onyx loam occupies nearly flat areas, and, where runoff from the uplands collects and remains, the soil is heavier textured and more compact when dry than is the typical soil. One of these areas is affected with high concentrations of alkali. At a point 4½ miles south of Vantage along the Columbia River the surface layer, about 9 inches thick, consists of light grayish-brown compact and vesicular loam. In the upper part the material breaks into friable laminated plates; in the lower part, into laminated blocks. The subsurface layer, which continues to a depth of about 26 inches, is olive-brown silty clay. Although compact, this material breaks into irregular clods. The underlying material, between depths of 26 and 50 or more inches, is light grayish-brown silt loam that is moderately compact and massive and breaks into single grains. This material is probably wind-laid. Loose river gravel underlies this soil at widely varying depths. Because of the heavier texture, underdrainage here is much slower than in typical Onyx loam of the Kittitas Valley.

Onyx loam occurs in widely scattered areas in the Kittitas Valley, in the valleys of Swauk Creek and Teanaway River, and near Nelson. All these areas are irrigated. An area of about 550 acres along the Columbia River is largely nonirrigated and is used only for grazing.

The relief is, for the most part, gently sloping. The small gravelly fans lying immediately under the foothills have a moderate slope. In most places both surface drainage and underdrainage are very favorable.

Onyx fine sandy loam.—Because of its light texture and droughty character, Onyx fine sandy loam is not well suited to grain under dry farming, but it is adapted to alfalfa and potatoes under irrigation.

The 6- to 12-inch surface layer of this soil consists of light-brown fine sandy loam that is slightly compact and without structure. It is underlain to a depth of 5 feet or more by lighter brown fine sandy loam or loamy fine sand that is very friable and easily crushed to single grains. The underlying substratum of this soil consists of

gravelly outwash valley-filling materials or older buried soils, over which this soil material has been superimposed.

Onyx fine sandy loam covers a total area of only 576 acres. The largest of the widely scattered areas are in Manastash district, principally south of Dammon School. Three small areas are near Vantage on the Columbia River. The surface is gently sloping. Underdrainage is generally excessive, and frequent irrigation is necessary.

Yakima loam.—Yakima loam is adapted to all the common crops and is especially valued as farm land because there is an abundance of irrigation water available for distribution through low-cost ditches.

The surface layer of Yakima loam, where typically developed, consists of medium-brown gritty loam containing some coarse sand and pebbles. It is slightly or moderately compact but very friable and breaks into soft clods. The subsurface layer, lying between depths of about 6 and 12 inches, is brown sharply gritty loam. This material also contains some small pebbles. It is compact but friable and forms soft clods. The subsoil is light-brown compact massive and vesicular harsh gritty loam, breaking into large friable chunks. Some gravel is embedded. At a depth of about 36 inches the subsoil rests on the underlying substratum of stream-laid gravel beds, generally consisting of fine gravel in the upper part and of coarser gravel, cobbles, and boulders below.

Yakima loam is an alluvial soil of recent deposition and occupies the alluvial bottoms of the Yakima River and its tributaries.

Several variations in depth, texture, and color had to be included in mapping. The depth of the soil material above gravel ranges from a few inches to several feet within short distances. The texture ranges from light gritty loam to clay loam, and in some of the partly filled old stream channels it is silty clay. At the higher levels, in some places 30 to 40 feet above the river, the soil has developed a rather rich-brown color, and here is transitional to the Naches soils. The more recently deposited soil material of the lower levels near the streams is grayer. Many gravelly areas are included and are shown on the map by gravel symbols.

In most places the water table is low enough to allow free internal drainage, and a large part of the soil is droughty, requiring frequent irrigation, especially in the shallow gravelly patches. As the rise of capillary moisture from the ground water is interrupted by open porous gravel, Yakima loam is almost entirely free from accumulations of alkali. Although typically well drained, a number of low-lying areas are included that are subject to the rise of underground water during high water and after heavy irrigations, and to overflow during floods. Many areas of this soil between Cle Elum and Easton are subjected to inundation during periods of high water and are interrupted by stream channels, sloughs, and swampy areas. In this locality very little land has been cleared of the thick growth of timber and brush.

The total area of Yakima loam is 7,872 acres. It is well adapted to all the common crops and produces good yields of alfalfa, grain, and potatoes. Because of the varying depth to gravel, however, distribution of irrigation water is not always uniform, and crops show an uneven growth and a varying time of maturity.

Yakima fine sandy loam.—In most places Yakima fine sandy loam is well drained and droughty. Although a good soil for alfalfa and potatoes, it is rather light-textured for heavy production of grain. Nevertheless all the common crops, including grains, are grown.

The 9- to 14-inch surface soil consists of brown fine sandy loam that is only slightly compact and structureless. The underlying soil material to a depth of about 36 inches is brown loamy fine sand that is slightly to moderately compact and structureless. This is underlain by stream-laid gravel.

About 4,608 acres of this soil is mapped, mainly in association with Yakima loam. Like the loam, this soil is gravelly in many places and variable in depth. There are many gravel bars, sloughs, and abandoned stream channels within the soil areas. The areas of pronounced gravelly character are indicated on the soil map by gravel symbols.

Yakima very gravelly sandy loam.—This soil is quickly affected by drought and is of little value for either crops or grazing, but it produces timber along the upper Yakima River.

The surface soil is light-brown gravelly sandy loam containing a large quantity of rounded gravel. At a depth of 4 to 12 inches it rests on slightly lighter brown loose open coarse sandy loam of high gravel content. This material grades into loose river-laid gravel and sand.

An alluvial soil of recent deposition, Yakima very gravelly sandy loam occupies large areas along the upper Yakima River and on the Columbia River. Smaller bodies occur in the stream bottoms of the Kittitas Valley. The total area is 7,232 acres.

This material differs very little from riverwash, except that it lies higher and is above the present overflow of the streams. The surface in many places is uneven; differences of several feet in elevation occur within short distances. Some areas are strewn with cobblestones. Included narrow strips of fine sandy loam or loamy fine sand are common in some places, but they are too small to be of any value for cultivation.

WELL-DRAINED SOILS WITH IMPERFECTLY DRAINED INCLUSIONS

The soils of the subgroup of well-drained soils with imperfectly drained inclusions, represented by two members of the Naches series, are extremely variable in texture of the surface soil and in character of the subsoil and substrata. Although the lighter textured member is typically underlain by readily permeable gravel and finer materials, small and intimately associated areas occur in which the subsoil materials include lenses and layers of much less permeable sandy clay and clay. These areas in general are too small to be accurately shown on the soil map. They are more pronounced and more extensively developed in the heavier textured member of the series, where they limit permeability and rapidity of subdrainage. Some of the lower lying areas are subject to a high water table during wet periods in spring and early summer. The lighter textured soil having the more permeable subsoil does not retain moisture well in the late summer and requires frequent irrigation, and in the lower lying areas of the heavier subsoil artificial drainage is necessary for most effective utilization.

Naches fine sandy loam.—This soil produces moderate to good yields of the common crops. Practically all of it is under irrigation and has been farmed for many years.

Where typically developed the 6-inch surface layer consists of brown harsh fine sandy loam that is compact and laminated and breaks into fine granules. It is underlain to a depth of about 16 inches by a subsurface layer of similar color and texture, containing some pebbles and gravel. This layer is compact and has a platy structure in the upper part and a blocky structure below. The upper subsoil layer, between depths of 16 and 22 inches, is gritty loam or clay loam, somewhat richer brown than the overlying material. Pebbles and gravel are embedded in this material, and it has a compact consistence and a prismatic structure. The lower subsoil layer consists of coarse gravel and cobbles embedded in slightly reddish brown loamy interstitial material. At a depth of about 60 inches this in turn rests on coarse uncemented gravel and cobbles, which extend to considerable depth.

A darker, shallower, and imperfectly drained soil, which occurs in several narrow areas in secs. 28 and 31, T. 18 N., R. 19 E., and secs. 7, 11, and 18, T. 17 N., R. 19 E., is included and is shown on the soil map by marsh symbols.

Areas of Naches fine sandy loam that have considerable gravel and cobblestones on the surface are shown with gravel symbols.

Another variation of this soil occurs in scattered areas along the high, sloping, northern margin of the basin of the Kittitas Valley, in association with the soils of the upland. It has a surface soil very similar to that of the typical soil, but it is underlain by outwash deposits of very coarse gravel and stones.

Bodies of Naches fine sandy loam aggregate 11,776 acres and lie mainly in the central and northeastern parts of the Kittitas Valley. One large body is just west of the town of Kittitas and another east of Ellensburg.

The surface is gently sloping, as the gradient ranges from 25 to 100 feet to the mile. The bodies of this soil type generally lie slightly above the surrounding soils, the subsoil and substrata are more permeable than in the heavier textured Naches soils, and surface drainage and subdrainage are favorable, except in small areas here and there where the water table is high.

All the common crops of the Kittitas Valley are grown and return moderate to good yields. This soil is well suited to alfalfa except where drainage is insufficient. As on other older farm lands of the valley, crop yields, particularly of alfalfa, have declined, owing probably in part to depletion of phosphorus.

Naches clay loam. All this soil is under irrigation and produces fair to good yields of crops.

Where typically developed, the surface soil consists of dull-brown or medium-brown light-textured gritty laminated or finely granular loam to a depth of 3 inches, resting on a 6-inch layer of clay loam that is compact in place but fairly friable when cultivated. This material is laminated in the upper part and blocky below. The upper subsoil layer, to a depth of about 18 inches, is rich-brown or olive-brown compact and roughly prismatic sandy clay or clay loam, breaking into angular vesicular clods and nutlike structural units.

This layer is somewhat friable when dry but very tenacious when wet. In the areas having a heavy subsoil, the lower subsoil layer between depths of 18 to 25 inches, is light yellowish-brown massive and vesicular clay loam or sandy clay, which extends down to the underlying brown-stained coarse gravel.

The depth of this soil over the gravel is variable, ranging from ½ to 5 feet or more, and in small included areas a comparatively large quantity of gravel and cobbles is present in the surface soil. These areas are indicated on the soil map by gravel symbols. An area in secs. 8 and 9, T. 17 N., R. 18 E., contains fine angular basalt fragments in the surface soil.

Naches clay loam occupies 8,064 acres, principally in the vicinity of Ellensburg and opposite this town on the southwest side of the river. Small or medium-sized areas are east of Coleman Creek and in the Manastash district along the highway between Ellensburg and Thorp and southeast of Dammon School.

The relief is gently sloping and undulating, and the general surface level is slightly higher than that of the surrounding soils. Surface drainage is adequate except in small scattered depressions and in shallow drainageways. Irrigation water is absorbed slowly, and the escape of water into the gravel below is retarded by the heavy-textured subsoil and upper part of the gravel substratum except in the included areas in which the clay layers are absent. In general the water table does not stand high enough in the gravel to limit the production of crops. In the more nearly flat areas the soil is difficult to irrigate properly because of the slow rate of absorption and the tendency toward waterlogging in the surface soil. Frequent light irrigation is the best practice.

Alfalfa, other hay crops, and grain produce fair to good yields. The cobblestones have been removed from many of the gravelly areas (pl. 4, *A*), but many fields are difficult to till because of the coarse gravel and cobblestones remaining in the surface soil.

IMPERFECTLY DRAINED SOILS

The soils in which inadequate drainage conditions are often present include members of the Esquatzel, Kittitas, Ahtanum, Woldale, Nanum, and Wenas series.

The Esquatzel and the Kittitas soils are characterized by deep, fine, generally uniform textures. In general they do not have impermeable heavy-textured subsoils, although stratified layers of silty or silty clay texture occur in places in the underlying materials. Porous beds of gravel in the substratum also occur in places, but as a rule they are not continuous. Under natural conditions surface drainage is adequate in most places. Movement of water through the subsoils, however, is somewhat retarded by the fine-textured soil materials, and in places the soils have been subjected to accumulated seepage waters and salts from the irrigation of adjacent higher lying areas.

The soils of this group having more impermeable subsoils and substrata include the Ahtanum, Woldale, Nanum, and Wenas soils.

The Ahtanum soils have fine-textured subsoils in which thin intermittent hard plates of cemented lime and alkali have developed. In general characteristics of the Ahtanum soils are related to the Kitti-

tas soils, but they are distinguished from them by a lighter color and some cementation in the lower layers.

The Woldale and Nanum soils have dense compact clay and clay loam subsoils. The Wenas soils occupy lower lying areas where surface drainage is less well developed and overlie gravel embedded in fine-textured, compact materials, in many places interbedded with compact silt and clay. The larger part of these soils is successfully used for crops. Some of the areas, however, are no longer productive, and continuous use is handicapped by serious drainage problems.

Esquatzel very fine sandy loam.—This soil is adaptable, easy to till, and easy to irrigate. Where it is protected from seepage and accumulations of alkali it produces good yields of all the commonly grown crops, especially alfalfa (pl. 5, *A*) and potatoes.

The upper 2-inch layer of the surface soil consists of grayish-brown very fine sandy loam that is loose and composed of single grains. Below this the material, to a depth of about 18 inches, is brown very fine sandy loam that is slightly compact and firm but soft and permeable. Widely spaced vertical cracks extend downward from a point near the surface to a depth of 12 or 14 inches, and the soil breaks into large soft blocks that crush easily into a mass of single grains. This is underlain by lighter brown looser material containing a slight to moderate accumulation of lime, which effervesces mildly with dilute hydrochloric acid. The parent material, lying between the depths of 34 inches and 6 feet or more, consists of light-brown very fine sandy loam or loamy very fine sand. This material is slightly compact and noncalcareous or only feebly calcareous. It is underlain at a variable depth by stratified beds of fine gravel, sand, or, in some places, silt or clay (pl. 5, *B*).

The depth of the soil material to the underlying bedded sediments is in few places less than 4 feet and in many places more than 8 feet. As mapped, this soil includes some variation in texture, as in many places it has been modified by local alluvial outwash of variable character.

Esquatzel very fine sandy loam occurs in the eastern and central parts of Kittitas Valley along Parke, Johnson, and Badger Creeks and below the hill slopes of the Edgemont district. It covers a total area of 1,984 acres. A number of small narrow bodies occur along Squaw Creek, Schnebly Coulee, and elsewhere in the eastern end of the county in the range lands. Such areas are included on the reconnaissance map with the soils of the semiarid upland—the Renslow-Selah soils.

Esquatzel very fine sandy loam occupies gently sloping or nearly flat areas on the intermittent stream bottoms and basin lowlands, generally near the loess-covered hill slopes.

In most places surface drainage and underdrainage are sufficient to prevent an accumulation of excess ground water under natural conditions, but where adjacent uplands are irrigated for a number of years, seepage and accumulation of alkali are inevitable unless the land is protected by intercepting drains. In common with other low-lying, deep, smooth-textured soils, this soil shows a marked tendency to accumulate alkali salts in the surface soil wherever a high water table occurs. Patches of so-called alkali salts are appearing in this soil along Badger Creek and other places where irrigation has been practiced for only 5 years.

Kittitas silt loam.—Kittitas silt loam is very similar to the Esquatzel soil, but it is distinguished from it by a darker color.

Where typically developed the surface soil to a depth of 4 inches consists of dark dull-brown silt loam that is slightly compact and very granular. The surface soil is underlain to a depth of about 48 inches by dark dull-brown silt loam that is but slightly compact, massive, and somewhat granular. In places this soil layer is streaked and blotched with dark stains, owing to the presence of sodium carbonate, commonly called black alkali. The deep subsoil is medium olive-brown heavy loam or clay loam. This material is compact in place but breaks easily into friable cloddy and vesicular aggregates. At a depth of about 70 inches it rests on water-laid valley-filling sediments of gravel, sand, and clay.

In places a subsurface layer and, more particularly, an upper subsoil layer occur, which are more compact than the layer between depths of 4 and 48 inches, described above. As mapped, some areas are included that resemble Woldale clay loam, which has a heavy clay subsoil layer, and other areas are more like the lighter colored Ahtanum soils.

Kittitas silt loam occupies 3,264 acres in the eastern part of the Kittitas Valley. The largest part lies east of Kittitas and continues up Caribou Creek. A long body borders Parke Creek.

This soil occupies lowland valleys, in which the relief is gently sloping and drainage conditions are much the same as in the Ahtanum soils. Some areas are comparatively free from so-called alkali and well suited to the production of all the common field crops. The greater part of the land is producing fair to very good yields of hay, grain, and potatoes, although small areas here and there have such a concentration of salts that they are used only for pasture (pl. 4, *B*).

Ahtanum loam.—Ahtanum loam has a high potential value, and where comparatively free from salts will produce good yields of all the common field crops of the valley.

Where typically developed, this soil has a 2-inch surface layer of light grayish-brown smooth loam that is moderately compact and laminated. This is underlain to a depth of about 12 inches by slightly gray light-brown smooth silty loam. The material in this layer is compact, massive, and vesicular, breaking into large chunks that are friable and easily crushed. The upper subsoil layer, between depths of 12 and 24 inches, consists of light-brown mildly calcareous smooth slightly compact soft very friable loam. The subsoil layer to a depth of 30 inches consists of brown highly compact loam or clay loam, more or less cemented by lime and salts into thin hard lenses and plates and in some places penetrated by roots. This layer is mottled and streaked with gray lime and effervesces strongly with dilute acid. Though rather hard, the cemented fragments can be broken with the hands. The lower subsoil layer below the indurated part and reaching to a depth of about 60 inches is light-brown slightly compact and somewhat vesicular smooth loam having gray saline streaks that effervesce strongly in acid. The deeper parent material is similar to the soil material and extends down to beds of stratified fine gravel, sand, or clay, which lie from 5 to more than 10 feet below the surface.

Ahtanum loam is of smooth silty texture inherited from the parent loessial material, which is high in very fine sand and silt. Generally it effervesces with dilute acid, owing to the presence of soluble carbonates, and lime has accumulated in the subsoil in most places. In this county this type of hardpan has been found only in this soil and is invariably associated with alkali. The hardpan is intermittent and occurs in about one-half of the area of the soil. In some places it is a mere crust about an inch thick; in other places it occurs in lenses or lumps; and in still others, within a short distance, it is a solid layer nearly a foot thick. The hardpan probably prohibits the downward movement of water in only a few small areas where it is especially thick and continuous.

Ahtanum loam lies on the gently sloping comparatively flat valley floors southeast of Ellensburg and southwest of Kittitas. It extends from 1½ miles east of Thrall to a point beyond the town of Kittitas and covers a total area of 4,800 acres. It is developed from the same loessial material as the Esquatzel soil, accumulated in valley areas by wind and water, and under the influence of a stagnant ground-water table, which favors the accumulation of alkali salts. Although the water table is commonly 5 feet or more below the surface, the physical character of the soil is such as to promote the capillary movement of water from the water table to the surface soil, where the salts in solution are concentrated by evaporation of the water into the dry atmosphere.

The concentration of salts in the soil varies greatly from place to place, according to the rate at which water can escape below through underdrainage and the degree of leaching that has taken place through irrigation. In about a third of the area of this land the salts are in such concentration that the land provides only saltgrass pasture. Although the larger part is used for crops, it would be benefited by a more extensive system of deep ditches to provide leaching of the salts downward and away in the underdrainage water. There is comparatively little development of the harmful defloccula-tion that causes some alkaki soils to run together and become impervious.

Where comparatively free of salts, Ahtanum loam is adapted to all the common crops of the county, particularly alfalfa and potatoes, and it would produce good yields of hops or sugar beets.

Woldale clay loam.—Woldale clay loam is one of the most productive soils for grain and hay crops, other than alfalfa.

In typical areas this soil has a thin surface layer, about 1 inch thick, of dark grayish-brown very finely granular and mellow clay loam, overlying a 3-inch layer of similarly colored clay loam that is thinly laminated in the upper part and of platy structure or cloddy below. This material breaks into granules. When the soil is wet the color darkens and appears nearly black. The subsurface layer, between depths of about 4 and 12 inches, is similar in color to the overlying material and consists of compact clay loam that breaks out into granular clods. Below this, the upper subsoil layer of dark grayish-brown clay loam is more compact and is somewhat less friable. It breaks into hard irregular clods and nut-size aggregates. This grades into sandy clay in the lower part. Between depths of 20 and 28 inches the subsoil is dark grayish-brown sandy clay mottled

with rich brown. It is compact, massive, and vesicular in structure, breaking into irregular clods. Below this and continuing to a depth of about 37 inches, the lower subsoil layer is slate-gray gritty sandy clay having a compact, massive, vesicular structure. Worm holes in this layer are stained yellowish brown. The gritty sandy clay is underlain by light greenish-yellow heavy clay or sandy clay highly mottled with yellow and red. This material is decidedly tenacious and impermeable. The substratum commonly consists of stratified beds of gravel containing yellowish or greenish clay layers in the upper part.

As mapped, several soils in which the subsoil layers vary somewhat in thickness and depth below the surface are included. Here and there the clay thins out or is absent for short distances and the dark clay loam surface soil directly overlies the gravelly clay at a depth of 2 to 4 feet. The lower subsoil layer of very heavy tenacious greenish-gray or greenish-yellow clay, however, is present throughout most of the area occupied by this soil.

An area of lighter colored and lighter textured soil occurring along the highway at Woldale School is included in mapping. It lies slightly higher than the surrounding land, and the lighter textured subsoil allows better drainage than prevails in the typical soil.

A number of small low-lying wet marshy areas along Coleman Creek are included and are shown on the map by marsh symbols. In some places the ground is marshy throughout the year and is covered with willows, dogwood, and other shrubs. Elsewhere in these areas the soil remains wet and waterlogged until late in the spring. The surface soil here, being very high in organic matter, is black. This land is used only for pasture or for wild hay.

Although this soil apparently is formed from loessial material similar to that of Esquatzel, Ahtanum, and Kittitas soils, distributed by wind and water over old gravelly valley-filling deposits, under the influence of higher moisture conditions it has developed a darker color, a finer texture, and a clay substratum.

Woldale clay loam is a fairly extensive and important agricultural soil. The typical areas are gently sloping or nearly flat and lie at various levels above the valley floor throughout the lower lying part of the Kittitas Valley. The largest bodies are associated with bodies of the Ahtanum and Kittitas soils (pl. 4, *B*) between Ellensburg, Kittitas, and Thrall. Several areas are along the highway northwest of Ellensburg and across the river along the road to Thorp. The total area is 9,600 acres.

The relief is very favorable for tillage and irrigation, but both surface drainage and internal drainage are impaired. Although this soil is not generally well suited to alfalfa, because of slow drainage, it is one of the most productive soils for other hay crops and grains, particularly oats, which yield as high as 140 bushels to the acre under normal conditions. Yields of 60 bushels of wheat are not exceptional.

Although the greater part of this soil would be distinctly benefited if artificial drainage were provided, it is probably the most difficult soil to drain in the Kittitas Valley. Any attempt to establish underdrainage discharging into large open ditches would probably prove difficult because of the impermeable character of the clay subsoil.

Intercepting drains to protect this land from seepage and runoff water from the higher lands should prove more feasible. Alkali salts are present in slight to moderate concentrations in a few places along lower Caribou Creek and elsewhere. Slick spots, where deflocculation of the fine material by alkali salts has caused the soil to run together when wet and to bake hard when dry, occur in the areas of this soil southeast of Ellensburg.

Woldale clay.—Woldale clay, an inextensive and unimportant soil, occupies nearly flat poorly drained areas containing some alkali spots.

The 3- or 4-inch surface layer consists of very dark gray or nearly black clay that is very sticky and puddled when wet but friable and granular when dry. The subsurface layer, extending to a depth of about 18 inches, is dark-gray clay. In the lower part of this layer the material is compact and very tenacious. The subsoil of greenish-gray very heavy tenacious clay overlies dark-stained coarse gravel and cobbles at a depth of 24 inches. In some places gravel and cobblestones occur in the surface soil.

Only 384 acres of this soil is mapped. The largest body, comprising about 300 acres, lies 2½ miles north of Kittitas. The land is used principally for pasture.

Nanum loam.—Although imperfectly drained, a large part of this soil is used for grain and hay crops.

Where typically developed, this soil has a surface layer, about 2 inches thick, of dark grayish-brown very friable and finely granular loam, underlain by dark grayish-brown compact loam that is laminated in the upper part and is platy and blocky in the lower part, breaking into soft clods when disturbed. Between depths of 8 and 22 inches the subsurface layer consists of dull grayish-brown compact and rather massive clay loam, breaking into rather soft blocks and clods. Below this the upper subsoil layer, about 7 inches thick, is medium dull grayish-brown compact and vesicular clay forming small hard prisms. The lower subsoil layer, lying between depths of about 29 and 33 inches, is light yellowish-olive compact vesicular sandy clay. Like the overlying material, it forms small hard prisms, but these prisms are mottled with iron stains. This material is underlain, to a depth of 10 feet or more, by yellow-stained gravel embedded in yellowish-brown sandy clay and very fine gravel.

As mapped the depth to gravel ranges from 18 to 40 inches and the clay subsoil layers in some places thin out or disappear. Areas having gravel and cobblestones in the surface soil are common and are indicated on the soil map by gravel symbols.

Areas of this soil are gently sloping or nearly flat and generally lie slightly lower than the surrounding land. Surface drainage is slow, and the underdrainage is impaired both by the clay subsoil and by the high water table in the underlying gravel. The need of drainage varies considerably. Some of the land would be definitely benefited by artificial drainage, but the problem is complicated by the fact that much of the land is now producing good yields of crops and subirrigation in some places is considered desirable.

Occurring only in the Kittitas Valley, Nanum loam lies principally in the northeastern part between Ellensburg and Caribou Creek. Several small bodies occur in the Manastash district. This soil occupies a total area of 384 acres.

A, Wheat on an area of Naches clay loam, originally gravelly and stony, from which the stone has been removed. (Courtesy of Washington State Works Progress Administration.) *B*, Dairy ranch pasture on saline area of Kittitas silt loam; Woldale soils, only slightly affected by salts, on left.

A, Alfalfa on Esquatzel very fine sandy loam. *B*, Cut bank on Johnson Creek showing profile and underlying fine-textured sediments of Esquatzel very fine sandy loam. (Courtesy of Washington State Works Progress Administration.)

Although some of the poorly drained areas of this soil are used for pasture, a large part is devoted to hay crops, consisting principally of timothy and clover, and to grain. It is good soil for oats. Only the better drained areas are suited to alfalfa.

Wenas loam.—Wenas loam was the first land to be taken up and farmed by the early settlers, because it would produce crops with little or no irrigation; and the larger more uniform areas still produce good yields of grain and hay.

To a depth of 12 to 18 inches the surface soil in typical areas consists of dark grayish-brown moderately compact loam that breaks into friable granular clods. The upper subsoil layer, reaching to a depth of 24 to 30 inches, is dark-gray heavy gritty compact loam or sandy clay loam, mottled with reddish-brown spots and streaks. The lower subsoil layer is very dark bluish-gray compact and tenacious sandy clay that is perennially wet and is stained blue or green from deoxidation and poor drainage. At a depth of about 40 inches, it generally rests on stream-laid gravel.

Wenas loam occurs in small stream valleys and in low subirrigated areas associated with the Yakima soils on the river bottoms. Several small tracts of dark or marshy soil on the low terraces in the valley of the upper Yakima River are included in mapping. The larger areas border the creeks that flow into the Kittitas Valley. This soil occupies 8,128 acres in the detailed survey. Small areas border the mountain streams and are included with local stream-valley soils as valley land, undifferentiated, on the reconnaissance map.

Drainage conditions vary greatly, but for the most part the water table is high in this soil because of the low position. The gradients of the stream valleys are generally sufficient to allow the provision of some artificial drainage by a small amount of ditching and straightening of stream channels. Little of this has been done, however, because subirrigation of these lands is in many places considered desirable and accumulations of alkali salts are rare.

Grain and hay normally return good yields and alfalfa does well on the better drained areas. The wetter areas are valuable for pasture and furnish some wild hay.

As mapped, a number of variations having considerable range in color, depth, and texture are included with the typical soil. In many places the surface is interrupted by winding stream channels and low marshy patches, and many small bodies of stream-wash gravel and strips of soil with cobbles and gravel on the surface, generally too small and intricate to show on the map, are also included. Other inclusions consist of small bodies of dark-brown fine sandy loam lying principally along Nanum Creek, numerous marshy areas of black muck, and shallow accumulations of peat.

Wenas gravelly loam.—In Wenas gravelly loam the gravel substratum occurs at a slighter depth than in Wenas loam, and variable quantities of gravel and cobblestones are present in the surface soil. Variations and inclusions in color and texture of surface soil similar to those occurring in Wenas loam are included.

This inextensive and unimportant soil occurs mainly in narrow belts and strips in association with Wenas loam. Some of the areas have been cleared or partly cleared of gravel and cobblestones and are

utilized for general farm crops with fair results; others are so gravelly and stony that cultivation never has been attempted, and the land is used mainly for pasture.

SOILS OF THE HUMID AND SUBHUMID UPLANDS AND STREAM VALLEYS

Soils of the humid and subhumid uplands and stream valleys include the soils of the timbered and prairie areas in that part of the detailed survey west of the Kittitas Valley basin. In this comparatively small area there are a number of soils that do not occur in the semiarid part of the county. So far as is known, most of these are confined to this basin and have not been recognized elsewhere.

The soils of the uplands and stream valleys developed under a humid climate and forest cover are leached of their lime, are low in organic matter, and are less fertile and wholly different in profile characteristics from the soils of the semiarid and subhumid grasslands. Most of these soils are well drained. In addition to the soils described under this head, the Yakima soils, included with the soils of the semiarid stream bottoms, where they are typically developed, extend into this area in the stream bottoms.

Soils of the prairie occupy either open treeless prairielike and meadowlike areas or open woodland.

Supplemental irrigation during the summer is necessary for the production of full crops on the well-drained soils, even in the most humid part of the county.

These numerous and diverse soil types are classified into subgroups according to drainage conditions.

WELL-DRAINED SOILS OF TIMBERED AREAS

The well-drained soils of timbered areas are members of the Teanaway, Cle Elum, Pend Oreille, Volperie, Bertolotti, Roslyn, and Springdale series.

Teanaway loam.—Teanaway loam is developed mainly on glacial boulder till under a forest cover of yellow pine and fir, and it is characterized by a gray or grayish-brown surface soil and a deep-lying mottled sandy clay or clay subsoil. Most of it lies above available sources of irrigation and is not cleared.

In typical virgin areas this soil has a thin surface layer, about half an inch thick, of decomposing pine and fir needles, overlying a layer, also about half an inch thick, of light, fluffy, dark grayish-brown loam that contains much organic matter. This is underlain by a thin layer, about 1 inch thick, of slightly compact but very friable loam of laminated or platy structure. This, in turn, rests on light grayish-brown loam having a light-pink tint and extending to a depth of about 17 inches. The material is moderately compact, massive, and vesicular and breaks into large friable chunks. Some pebbles and rock fragments are present. The upper subsoil layer consists of light grayish-tan loam, mottled with brown in the lower part. This material is compact, massive, and finely vesicular, breaking into friable irregular clods. At a depth of about 26 inches it gives way to light grayish-brown very compact massive vesicular loam mottled with gray and deeper brown. The lower subsoil layer, lying between depths of 42 and 56 inches, is rich-brown clay or sandy clay mottled slightly with

gray. This material is very compact and hard when dry and breaks into sharp irregular clods. It grades below into a gritty boulder clay till.

The relief of Teanaway loam is undulating or very hilly. As mapped in the undeveloped timberlands, boundary lines are generalized, and rather wide variations in depth and stoniness as well as small bodies of other soils are included. The typical soil is generally free from stones on the surface, except for a few erratic boulders. An inclusion lying in the vicinity of Peoh Point and westward toward Cle Elum Creek is browner, more compact, and heavier textured in the subsoil layers than the typical soil. This inclusion is transitional to the reddish-brown Pend Oreille loam.

Teanaway loam occurs in the timbered uplands from Swauk Creek to the western limits of the foothills of Lookout Mountain, in the uplands in the bend of the Teanaway River, and on the south side of the Yakima River from Horseshoe Canyon to Cle Elum Creek. It occupies a total of 7,552 acres in the area of the detailed survey. Outlying areas of this soil are included with rough mountainous land on the reconnaissance map.

Most of the land lies above irrigation, and only a very small acreage has been cleared for cultivation. The soil is only moderately productive without the use of fertilizers, and under present farm prices further clearing of the timbered areas generally is not warranted. Below the Highline Canal, however, in the Peoh Point district, several hundred acres of this land has been cleared and put under cultivation. In the experience of those who have tilled this soil, from 3 to 5 years are required to bring it into profitable production. According to popular opinion, this initial lack of productivity is due to toxic substances, or "turpentine," left in the soil by the pine and fir trees. More likely, however, it is due largely to the leached and acid condition of the surface soil, which is deficient in plant nutrients, particularly nitrogen.

Teanaway loam, terrace phase.—Teanaway loam, terrace phase, occurs on high terraces south of the Yakima River. Only 1,600 acres are mapped. The largest area (about 650 acres) lies on the high glacial terrace opposite the mouth of the Teanaway River; another large area is on the terrace immediately south of Cle Elum.

This soil differs from typical Teanaway loam in having a more nearly flat surface, a slight buff color in the subsurface soil, and more compact structure and heavier texture of the subsurface and upper subsoil layers.

Nearly all of the land is under the Highline Canal, and about one-third of it is cleared and farmed. The gently sloping surface favors irrigation, and drainage is generally adequate. Fair to good yields of alfalfa, clover, other hay and grain crops, and potatoes are obtained after the land has been farmed a number of years.

Cle Elum fine sandy loam.—Most of this soil lies above the level of feasible irrigation, and, as it is droughty, little of it has been cultivated.

Beneath a thin cover of pine and fir needles the virgin soil has a 1-inch layer of dark grayish-brown faintly laminated fine sandy loam, over a layer, about 3 inches thick, of medium buff-brown fine

sandy loam with a slight yellow tint. This material is mildly acid, slightly compact, vesicular and platy in structure, but friable, and it breaks into soft granules. The subsurface layer, lying between depths of 4 and 10 inches, is buff fine sandy loam that is somewhat compact but friable and has a soft granular or crumb structure. It is underlain, to a depth of about 16 inches, by buff fine sandy loam that is compact, is vesicular and faintly platy in structure, and breaks into soft crumbs and granules. The next lower layer consists of light yellowish-buff fine sandy loam or light loam mottled with gray and brown. This compact, massive, vesicular material breaks into large fairly friable blocks. Below a depth of 36 inches the lower subsoil layer is light grayish-brown sandy clay slightly tinted with olive and mottled with gray and reddish brown. The subsoil grades into decomposing sandstone.

Typically, Cle Elum fine sandy loam is developed on massive sandstones of the Roslyn formation, which occurs in the uplands north of Cle Elum, in the vicinity of Roslyn and Ronald, and in the uplands north and east of the Teanaway River. The relief comprises moderate slopes to steep hillsides, which continue into areas of steeper rough mountainous land. Thin superficial deposits of stony glacial drift forming a veneer over the parent materials are common near Roslyn, Ronald, and Lake Cle Elum. Northeast of Cle Elum this soil merges with Teanaway loam, which is developed largely on glacial deposits. Cle Elum fine sandy loam has a total area of 6,528 acres.

Cle Elum fine sandy loam lies above existing means of irrigation, and the land has been cleared and cultivated to only a very small extent in the vicinity of the coal-mining towns and north of Ballard School. Outlying areas in the foothills north of Cle Elum and along the forks of the upper Teanaway River are included with rough mountainous land. This is a droughty soil of little agricultural importance and is best utilized for the production of timber and for grazing.

Cle Elum loam.—Although a productive soil under irrigation, Cle Elum loam is not important agriculturally because of its small extent.

The 3-inch surface layer consists of dark grayish-brown faintly laminated very granular, friable loam. The subsurface layer, extending to a depth of 10 inches, is dark grayish-brown compact granular loam. This gives way to medium dull grayish-brown heavy loam, which extends to a depth of 16 inches. This material is friable and breaks into coarse granules and nutlike units. Below this the material is grayish-brown compact but granular sandy clay loam. Between depths of 22 and 30 inches the lower subsoil layer is dull-brown clay mottled with gray and breaking into hard aggregates. This is underlain to a depth of 50 inches by dull-brown sandy clay mottled with gray and rusty-brown streaks.

Only 1,088 acres of this soil are mapped. It occurs on lower slopes in association with Cle Elum fine sandy loam principally in and near Cle Elum and Roslyn. It was developed largely under a brush and grass cover. This soil is productive when irrigated, but only small fields and gardens are cultivated in and near the towns. Three small irrigated areas in the Teanaway Valley return good yields of grain and hay.

Pend Oreille loam.—Only a small part of Pend Oreille loam can be irrigated by existing facilities. Although the soil is inherently productive, yields are limited by the short growing season and cool nights.

The virgin soil is covered with a 1-inch mat of decomposing fir, pine, and tamarack needles. Below this a surface layer, about half an inch thick, of dark grayish-brown organic light fluffy loam is succeeded by a 1-inch layer of light grayish-brown fine sandy loam containing lenses of white sand. This material is moderately acid. Between depths of 2½ and 18 inches the material is light reddish-brown light-textured gritty loam and contains some coarse material ranging from coarse sand to small gravel. The reaction is mildly acid. The material is only slightly compact and has no noticeable structure. The subsoil is light reddish-brown moderately compact loam that is mottled with gray and deeper red and breaks into irregular friable clods when moist and is hard when dry. Between depths of 36 and 50 or more inches the parent material is reddish-yellow slightly compact fine sandy loam containing embedded decomposing pebbles and gravel.

Pend Oreille loam is apparently representative of the upland zonal podzolic soil of the more humid western part of the area. It is developed under heavy fir and associated timber, mainly on glacial drift but also in part on mountain outwash and colluvial material of mixed mineralogical character. It occupies uplands and lower mountain slopes within the trough of the valley of the Yakima River west of Cle Elum. The relief comprises gentle slopes to steep hillsides. Gravel and stones are common in the surface soil. The soil material is leached and acid in reaction.

The Pend Oreille soils are formed under somewhat heavier rainfall and denser forest than the Teanaway soils, to which they are related. As developed in this county, the subsoil is somewhat more compact and has a better moisture-holding capacity than that of the soil as previously mapped.[6]

Only a small proportion of Pend Oreille loam has been cleared for cultivation. About 100 acres of this soil lies under the Highline Canal, and several small tracts are being farmed under irrigation. Despite the good productive capacity of the soil, yields are limited by the climatic environment. The principal crops are hay, grain, and potatoes. Alfalfa yields 2½ tons or more an acre under favorable conditions, and potatoes produce as much as 10 tons. Under present farming conditions, however, there is little inducement to undertake further clearing. Some grazing is afforded in cut-over and burned-over areas, but the thick woods offer little pasturage. Much of this land is best utilized in producing timber.

An area of 4,992 acres of Pend Oreille loam is included in the detailed survey of this area. Other bodies of this soil are included on the reconnaissance map with valley land, undifferentiated, and with rough mountainous land.

Volperie loam.—Typical Volperie loam developed from schist is probably too infertile to warrant clearing and is best utilized in producing timber and for what pasture it will afford. Most of the

[6] POULSON, E. N., MARK, F. A., and GIBBS, GEORGE. SOIL SURVEY OF BONNER COUNTY, IDAHO. U. S. Bur. Plant Indus., ser. 1934, No. 16, 66 pp., illus. 1939.

merchantable timber has been logged off, and none of the land has been cleared for cultivation.

Beneath a 1-inch mat of very dark brown leafmold, Volperie loam has a surface layer, about half an inch thick, of gray moderately acid light fluffy organic loam streaked with nearly white ashy material. The next lower layer, between depths of 1½ and 6 inches, is pinkish light-brown moderately acid very loose loam containing some hard granules and many small rounded decomposing rock fragments and shotlike pellets. This is underlain to a depth of 12 inches by light pinkish-brown slightly compact loam containing many hard coarse granules and decomposing rock fragments and shotlike pellets embedded in a soft ground mass. Below this, similar material that is slightly more compact extends to a depth of 18 inches. This gives way to light pinkish-brown clay loam that is compact and vesicular in structure. This material breaks into small angular clods that are hard when dry. At a depth of 24 inches is the partly weathered and decomposed parent schist bedrock.

Volperie loam covers only 384 acres on the hill slopes between Spexarth and Peterson Creeks. For the most part, it is developed in place on bedrock, which in many places outcrops or lies only a few inches below the surface.

On the soil map, small bodies of Pend Oreille loam developed on glacial drift are included with this soil.

Volperie loam, terrace phase.—Only a small part of this inextensive soil lies below the level of available sources of irrigation, and none of it is used for agriculture.

The surface of the terrace phase of Volperie loam is covered by a mat, about 1¼ inches thick, of decomposing needles from Douglas-fir and white fir trees. The 1-inch surface layer of ashy-gray very loose fine sandy loam is underlain to a depth of about 10 inches by light grayish-brown very loose loam having a soft-crumb structure and containing many decomposing pebbles and resistant fragments of quartz derived from the parent schist. This gives way to similar but more compact material that breaks into irregular blocks and fragments when disturbed. Beginning at a depth of 20 inches and continuing to a depth of about 30 inches, the subsoil is medium olive-brown clay having a smooth feel, owing to the large content of very fine particles of mica. This material is compact, breaks into irregular sharp clods, and contains embedded fragments of hard schist. It is underlain to a depth of more than 50 inches by olive-brown sandy clay that is moderately compact, breaks into large irregular blocks and smaller secondary fragments, and contains many small pieces of decomposing schist.

Volperie loam, terrace phase, occupies only 448 acres on the high terrace between Cle Elum and Spexarth Creeks. The relief is gently sloping and undulating. The soil is developed on mountain outwash material consisting mainly of fragments of the Easton schist. This soil has a cover of young coniferous timber and a few scattered larger trees. About 80 acres of this soil lies below the Highline Canal.

Bertolotti fine sandy loam.—Very little of this soil has been cleared for farming, as it has only a moderate productive capacity for agricultural crops.

In typical undisturbed virgin areas, dark forest litter, consisting mainly of fir and pine needles, overlies a thin or somewhat dispersed layer of light ashy-gray moderately acid siliceous material. The next lower layer consists of light grayish-brown loose mellow permeable fine sandy loam containing a few scattered small fragments of parent rock. The reaction is mildly acid. At an average depth of about 12 inches this material rests on dull yellowish-brown or pale reddish-brown rather coarse gritty loam that is slightly compact but mellow and readily permeable. This material is also mildly acid in reaction. At a depth of about 24 inches it rests on light-brown gritty loam having a slightly olive or greenish tint when moist and containing a large quantity of small angular fragments of parent igneous rock.

As mapped, Bertolotti fine sandy loam is variable in character. In some areas adjacent to the foot of the mountain slopes the soil is shallower than elsewhere, and in some places it is underlain by sand and gravel. Further differentiation of the minor variations and inclusions in the thickly timbered areas of minor agricultural importance is not believed to be warranted. Included gravelly and stony patches are common, particularly near the foot of steep mountain slopes.

This soil occurs on gentle to moderate marginal valley slopes from the Peoh Point district westward to Little Creek. Drainage is good. The parent soil materials are derived from light-colored igneous rocks. One isolated area occurs near the mouth of Little Creek. The total area mapped is 1,664 acres.

About 30 acres of this soil under the Highline Canal in the Peoh Point district is irrigated. As it is only moderately productive, most of the land appears to be of greater value for growing timber than for agriculture.

Bertolotti loam.—Bertolotti loam is very shallow, has low moisture-holding capacity, and has little value except for forestry.

The surface soil in undisturbed areas consists of thin dark grayish-brown light textured gritty loam, high in organic matter, underlain by loose light-gray sandy material containing some fine rock fragments. It rests on light grayish-brown loam in which fragments of schist and quartz rock are embedded. This material is underlain by light-gray micaceous loam containing many rock fragments, which become more abundant at a depth of about 15 inches.

As mapped, Bertolotti loam includes areas in which angular rock fragments are very abundant and in which the fine soil material ranges in texture from light loam to fine sandy loam. It is developed from outwash material. It covers an area of 832 acres, at the foot of the mountains between Cle Elum Creek and Spexarth Creek. The parent soil materials are derived mainly from Easton schist.

Roslyn fine sandy loam.—Although somewhat droughty, this soil returns comparatively good yields of the crops commonly grown.

Beneath a thin cover of pine and fir needles, the surface layer of the virgin soil is medium-brown very loose gritty fine sandy loam containing some coarse sand and fine gravel. At a depth of about 2 inches the color becomes slightly reddish brown, and at a depth of about 8 inches the material grades into light reddish-brown moderately compact loam faintly mottled with red and gray. The subsoil, lying between depths of 20 and 30 or more inches is reddish-brown gravelly loam mottled with red and gray. This material is vesicular and some-

what compact but breaks into clods. It grades at a varying depth into beds of brown-stained rather compact gravel, which commonly extend to a depth of many feet. The entire soil is friable and pervious and contains varying quantities of coarse material ranging from coarse sand to coarse gravel or cobblestones.

Small strips of Springdale gravelly sandy loam, too small to be shown on a small-scale map, are included. In areas mapped on the higher terraces south of Nelson and elsewhere in association with Pend Oreille loam, the soil is similar to Pend Oreille loam, the basis of separation being the nearly flat surface and the substratum of water-laid glacial outwash gravel of Roslyn fine sandy loam.

Roslyn fine sandy loam is developed under a coniferous timber cover on glacial outwash terraces that vary in age and range from 10 feet to more than 150 feet in height above the present level of the river. This soil occupies 4,288 acres on both sides of the Yakima River Valley from the Teanaway River to Easton. The largest body, covering about 1,900 acres, lies on the high terrace between Cle Elum and Roslyn, extending westward to the bluff along the Cle Elum River bottom. Areas of moderate size occur on the south side of the Yakima River opposite Cle Elum and westward along the Highline Canal.

The surface is nearly flat, sloping slightly toward the edges of the terraces and down the valley with the gradient of the river. This lay of the land is very favorable for tillage and irrigation. About 600 acres are irrigable under the Highline Canal. Being somewhat droughty, this soil requires frequent irrigation, but the crops commonly grown in the irrigated area produce comparatively good yields. Alfalfa and red clover yield as much as 3 tons and potatoes 10 tons an acre under favorable conditions. The uncleared land is used for grazing and forestry.

Springdale gravelly sandy loam.—A large part of Springdale gravelly sandy loam supports a forest cover. Only moderate yields can be expected from this shallow, droughty, and gravelly soil.

The 2-inch surface layer consists of dark-brown very loose gravelly sandy loam. It overlies a 4- to 6-inch layer of similar but yellowish-brown or slightly grayish brown soil material. Beneath this material very gravelly sandy loam extends to a depth of about 24 inches, where it grades into loose gravel and cobbles. The thickness of the surface soil and the quantity of gravel and cobblestones on the surface vary from place to place, and some small patches of deeper soil similar to Roslyn fine sandy loam are included on the map.

Springdale gravelly sandy loam, covering a total area of 3,776 acres, is associated with Roslyn fine sandy loam, but it generally occurs on lower terraces. This indicates that it is developed mainly on the outwash of the last glacial period, and it has a more open porous subsoil than does the Roslyn soil. The largest areas lie immediately south of Lake Kachess, on Big Creek, and southeast of Lake Cle Elum. The surface is nearly flat to gently sloping.

Although this soil is very shallow and droughty, some areas between Nelson and Easton have been cleared and are farmed under irrigation. The land is difficult to till because of the gravel and cobblestones, and only moderate yields can be expected. It requires very frequent irrigation. A large part of the land supports a growth

of young pine and fir. Large yellow pine trees remaining near the Cle Elum River indicate that the land will produce good timber.

IMPERFECTLY DRAINED SOILS OF TIMBERED AREAS

The imperfectly drained soils of the timbered areas are represented by soils of the Volke and the Quicksell series. Together these soils cover only 2 square miles. Surface drainage in the Volke soil, which occupies lower lying alluvial fan slopes, is fairly well developed, but subdrainage is somewhat retarded by the compact heavy subsoil. In the Quicksell soil both surface drainage and internal drainage are imperfect.

Volke sandy clay loam.—In undisturbed virgin areas the surface of Volke sandy clay loam is covered by a thin layer of decomposing pine needles. This rests on a 7-inch layer of dark dull-gray friable moderately compact sandy clay loam that is laminated or platy in the upper part and very granular in the lower part. The subsurface layer is slightly lighter gray gritty compact vesicular very coarsely granular sandy clay loam. At a depth of about 28 inches it overlies the subsoil of light yellowish-gray, faintly mottled with iron stains, compact massive vesicular sandy clay, which extends to a depth of 40 or more inches. This material breaks into sharp irregular clods.

Volke sandy clay loam occurs in only one area of 320 acres east of Lanigan Airport. It is developed on old alluvial material that has been derived from the Roslyn beds, carried down large coulees from the uplands, and deposited on the terrace on a gently sloping fan.

Surface drainage is adequate in most places, although subdrainage is somewhat retarded by the heavy compact subsoil. The natural vegetation consists dominantly of western yellow and lodgepole pine, cottonwood, aspen, and deciduous brush.

Volke sandy clay loam is fertile and productive, and it is well suited to all crops grown in the section in which it occurs. Nearly all of it is cleared and used for hay and grain under irrigation.

Quicksell loam.—Because of an impervious clay subsoil and a gray leached surface layer, Quicksell loam is comparatively infertile and not well adapted to farming. Nevertheless, a large part of it is cleared and farmed under irrigation, with generally unsatisfactory results.

Beneath a 1-inch layer of decomposing needles from yellow pine and Douglas-fir trees in virgin areas, the 3-inch surface layer consists of very friable leached light-gray smooth slightly compact silty loam having a finely vesicular laminated or platy structure. This is underlain to a depth of 10 inches by light-gray compact and vesicular loam, breaking into irregular soft chunks. Below this is light-gray compact massive vesicular loam faintly mottled with deeper gray. The upper subsoil layer, between depths of 22 and 28 inches, is olive-brown or greenish-gray very heavy clay, which forms small dense columns that are rounded at the tops and coated with ashy-gray material. The lower subsoil layer, extending to a depth of 50 or more inches, is light greenish-yellow or greenish-gray heavy massive and vesicular sandy clay. Fine pebbles are embedded in this material.

Quicksell loam is inextensive. It occupies a number of small nearly flat terracelike areas extending from the Lanigan Airport, to

a point a mile east of Teanaway School, between South Cle Elum and Benson, and southeast of Indian John Hill.

On one farm north of Teanaway a tract of this soil has been farmed for many years and has been heavily manured, used largely for alfalfa and clover, and made to produce fair yields of hay and grain. The undeveloped areas of this soil have a thick stand of small western yellow pine and Douglas-fir.

WELL-DRAINED SOILS OF THE PRAIRIE

The well-drained soils of the prairie have developed under a natural vegetation of grasses and herbaceous plants together with a few shrubs. They are represented by the soils of the Swauk and the Garrison series. These soils differ widely in profile, internal drainage, and moisture-holding capacity. The Swauk soil is developed on glacial till materials and has a compact subsoil and a compact substrata, which in places have developed a columnar solonetzlike structure. Surface drainage is good, but internal drainage is much slower than in the Garrison soil, which is developed on porous gravelly glacial outwash materials.

Occupying comparatively low flat areas on the terraces of the stream valleys, the Garrison soil has comparatively poor surface drainage, but internal drainage is excessive because of the loose, open, gravelly character of the material. It is developed under a grass cover in open parklike areas.

In character and location both these soils represent a transition between the soils of the semiarid area and the soils of the humid area. The Swauk soil is related to the Teanaway soils developed on similar materials under a timber cover. The Garrison soil is related to the Springdale soils developed on similar parent materials under a cover of young fir and pine.

Swauk loam.—Swauk loam is a fertile soil, but only a small part of it can be irrigated by available systems. Most of the rest is dry-farmed and used mainly for wheat.

Under a heavy cover of prairie grass in typical virgin areas, the 4-inch surface layer of Swauk loam consists of slightly grayish dull brown, slightly laminated, very finely granular, and friable loam. The subsurface layer is granular throughout and similar in color and texture to the surface layer, but it is slightly more compact and much more laminated or platy in the upper part. The upper subsoil layer, between depths of 12 and 20 inches, is medium dull-brown clay loam that is compact but friable and breaks up into granular aggregates. Below this is light-brown clay loam slightly streaked with gray, which, when it dries out, becomes gray. It is compact and massive and breaks into irregular sharp clods. At a depth of 27 inches it rests on rich-brown very heavy colloidal clay having a very pronounced columnar structure. The tops of the columns are rounded and are coated with a thin ashy-gray layer. The walls of the columns are also streaked with this gray coating. Between depths of about 42 and 60 inches the material is light rich-brown or dull yellowish-brown sandy clay, slightly mottled with gray and deeper brown. This material breaks into hard, sharp nutlike units and coarse granules. It overlies the parent glacial boulder till.

Swauk loam is most typically developed on Swauk Prairie under a heavy grass and herb cover and about 20 inches of mean annual

A, Dairy farm pasture on unirrigated area of Swauk loam in Horse Canyon. *B*, Area of stony and shallow soils developed on materials giving rise to the Manastash soils. The only use for these soils is for early pasture for sheep, and this is of low value.

precipitation. The surface is gently rolling. A number of narrow strips of dark-colored Latah clay loam, which occupies lower slopes and small depressions, are included. The prairie is fringed with yellow pine and fir, growing on the adjacent Teanaway loam. A few erratic glacial boulders lie on the surface, gravelly patches occur, and shallow spots of soil on the higher ground show where the surface soil has been washed away. Although the clay subsoil is dominant throughout the area of this soil, the pronounced columnar layer is not continuously developed at the higher levels.

The prairie soil of Horse Canyon (pl. 6, *A*), the south slope of Lookout Mountain, and Thorp Prairie are included with Swauk loam in this survey. The soil in Horse Canyon is very similar to Swauk loam, but it is developed on wind-laid and colluvial material and in places closely overlies basalt. On the slope of Lookout Mountain and Thorp Prairie, the rainfall is somewhat lighter and the columnar layer is developed only in the more nearly flat areas. On Thorp Prairie the soil has been eroded severely and is very patchy in association with strips of gravelly and stony scabland.

Small areas of prairie and park land farther west, within the timbered area, where the rainfall is heavier and the surface soil is grayer than in typical areas of Swauk loam, are also included.

The total area of this soil is 5,312 acres. It is a productive soil, but only a small proportion—the areas in the Teanaway and Peoh Point districts—is under irrigation. Most of the rest is used for growing wheat under dry-farming methods. It is necessary to summer-fallow every other year or every third year, and yields of wheat range from 10 to 15 bushels an acre on Thorp Prairie and from 20 to 30 bushels on Swauk Prairie. Yields have decreased in recent years, owing to the continuous cropping to wheat. On Swauk Prairie some early potatoes of the Irish Cobbler variety are grown, both for certified seed and for commercial sale. The yields range from 1 to 2½ tons an acre. Alfalfa produces one cutting of a ton or more to the acre, except in the driest years. Small acreages of peas grown for seed on Swauk Prairie during the season of 1936 yielded from 15 to 20 bushels an acre.

Garrison fine sandy loam.—All this soil is irrigable, and it is fairly productive, although yields of crops are limited by the cool short growing season.

The 10-inch surface layer in the virgin areas of Garrison fine sandy loam consists of very dark brown fine sandy loam containing some fine gravel. It is high in organic matter, loose, and almost structureless. Lying between depths of 10 and 20 inches, the subsurface layer is dull dark-brown loose fine sandy loam containing coarse sand and fine gravel. This is underlain to a depth of 30 inches by brown or yellowish-brown only slightly compact gravelly sandy loam, grading into dull-yellow gravelly sandy loam, which overlies beds of gravel at a depth of 40 or more inches.

Garrison fine sandy loam covers only 448 acres, in association with the Springdale soil on the low glacial outwash terrace between Nelson and Easton. It is in prairie and park areas developed under a grass and brush cover. The surface is nearly flat. Underdrainage is adequate, except in depressions. All the land can be irrigated by the Highline Canal, and practically all of it is now used for hay crops and grain.

IMPERFECTLY DRAINED SOILS OF THE PRAIRIE

The imperfectly drained soils of the prairie or open woodland and brush-covered and marshy areas are represented by the Latah and the Peoh soils. All these soils are inextensive, but, owing to their moist condition when drainage is controlled, they are productive and are of considerable local importance.

The Latah soils occupy local flats and drainage depressions, in association with the lighter colored Swauk soils, and have a solonetzlike profile. The Peoh soils have developed under half-bog conditions.

Latah clay loam.—Most of this soil is used for growing grains under dry farming with good results, and irrigated areas return profitable yields.

The 1- or 2-inch surface layer consists of dark grayish-brown laminated finely granular clay loam, resting on a layer, about 5 inches thick, of dark-gray compact clay loam that has a pronounced thin platy structure and is strongly acid. The subsurface layer, between depths of about 6 and 16 inches, is dark- or dull-gray compact clay loam or silty clay loam having an imperfectly developed prismatic structure. Below this an upper subsoil layer, about 4 inches thick, is gray vesicular silty clay having a prismatic structure and breaking into hard irregular clods and nutlike units that are streaked with gray along the lines of breakage. This layer is underlain, to a depth of 36 or more inches, by very dark slate-gray very heavy dense clay that is imperfectly columnar in structure. The tops of the columns are rounded and thinly coated with ashy-gray material. This clay overlies dull slate-gray dense massive clay that is faintly mottled with iron stains.

This soil occupies a small total area, chiefly in association with Swauk loam, on lower slopes and in depressions. As mapped, it includes marginal transitional material of slightly lighter color and texture. The largest bodies are at Swauk School and in Horse Canyon. Numerous small strips of this soil in a few depressions on Swauk Prairie are included with Swauk loam.

Most of the soil is used for dry-land grain farming and returns yields slightly higher than those obtained on Swauk loam. The areas of this soil near Ballard School and near Swauk School are irrigated and produce profitable yields of hay and grain.

Underdrainage is greatly impaired by the heavy-textured clay subsoil, and the land remains wet for some time in the spring. Surface drainage has been provided for the larger part of the farmed land.

Peoh loam.—Peoh loam is a fertile soil and requires no irrigation except in late summer.

This soil has a surface layer, about 8 inches thick, of very dark grayish-brown or black highly organic loam, which is moderately compact, breaking when dry into very friable granular clods. The subsurface layer, which reaches to a depth of about 19 inches, is dark brownish-gray fine-textured loam containing some gritty particles and fine rock fragments. This material is compact but very friable and breaks into granular clods. The subsoil is bluish-green clay that is mottled with yellow when wet and becomes light gray when dry. At a depth of 24 inches this clay abruptly overlies the parent material, which is sandy clay containing small decomposing

fragments of micaceous schist. This material is greenish gray when wet and light gray when dry.

Peoh loam is developed under marshy and half-bog conditions in small scattered depressions in the uplands of the more humid western part of the county. Apparently the underlying material is derived largely from Easton schist. Only a few small areas, totaling 320 acres, are mapped. A large part of this land has been cleared of the original cover of brush and small deciduous and cedar trees, drained, and either cultivated or used for pasture. Good yields of grass hay, clover, and oats are obtained when the soil is drained.

As mapped, this soil includes a few small areas between Cle Elum and Peterson Creeks, in which the subsoil materials are lighter gray, compact, massive, and comparatively impermeable. These areas occupy flat depressions, which, in the aggregate, cover only about 35 acres. Water stands on the surface in the spring, and the soil becomes baked and hard in the summer. This inclusion is of little agricultural importance.

Peoh clay.—Peoh clay is a strong fertile soil, and, where provided with surface drains and carefully farmed, it will produce heavy yields of grain.

The 1- or 2-inch surface layer of black or nearly black friable finely granular silty clay loam overlies a 16- to 18-inch layer of black heavy clay that breaks into hard sharp clods when dry. This is underlain to a depth of about 24 inches by black heavy clay having a rough prismatic structure and breaking into very hard irregular aggregates and clods. This material is slightly streaked with gray along the lines of breakage. The lower subsoil layer, extending to a depth of 50 or more inches, is slate-gray massive sandy clay mottled with red and yellow. The natural cover is brush and small trees together with small open grassland areas.

This soil is developed under half-bog conditions in slowly drained or undrained depressions and in seepy areas on slopes in the uplands. It is widely distributed in small bodies throughout the eastern part of the timbered section, but the total area is only 768 acres. The largest areas lie in the Peoh Point district and near Ballard School, where the greater part of the land is irrigable.

Peoh clay is limited to the production of timothy, red clover, wild hay, and grain because of its wet condition in the spring and its dense intractable physical characteristics. Yields of 120 bushels of oats and 60 bushels of wheat an acre are not exceptional.

Outlying bodies of this soil remain in brush and deciduous trees and are used for pasture.

Peoh silty clay loam.—Peoh silty clay loam is very similar to Peoh clay in all essential features except in the lighter texture and more tractable character of the surface soil.

Where typically developed the surface layer consists of very dark gray or black silty clay loam, 6 or more inches thick. This material is high in organic matter, finely granular, and friable, except where puddled or baked. The subsurface layer, reaching to a depth of about 12 inches, is very dark gray or black compact silty clay or clay, breaking into coarse granules and nutlike aggregates. Below this a layer of nearly black very dense tenacious clay extends to a depth of about 33 inches. When dry it breaks into hard sharp clods and nut-sized aggregates. A subsoil layer of drab, yellowish-brown, or gray

heavy massive clay, mottled with gray and rusty red, continues to a depth of 48 or more inches.

As mapped, the color and texture of Peoh silty clay loam are variable, because marginal strips are included in which the lighter colored and lighter textured timbered soils of the uplands grade into the half bog soils of the depressions and moist slopes. Small areas having a thin surface layer of loam and small patches of black muck, which occur in the marshy places, also are included.

This soil is more tractable than the heavier Peoh clay, and where surface drains have been provided it produces good yields of grain, clover, and grass-hay crops. It is very inextensive, occupying only 704 acres in the Peoh Point district and eastward to Indian John Hill. Practically all of it is farmed under irrigation.

ORGANIC SOILS

Although small areas of organic material of mucky and peaty character are included in most places with the imperfectly drained soils occupying low wet areas, a number of scattered small bogs and swamps have been differentiated on the soil map. These are of little present agricultural significance and represent a rather wide range in degree of decomposition of organic materials and in proportion of mineral matter. They are included under the general classification of peat without further attempt to identify this material in respect to parent organic materials or relation to types of peat identified in previous soil surveys.

Peat.—As occurring in this county, peat consists dominantly of brown or very dark brown organic material that is commonly well decomposed, although leaves, twigs, and plant roots in varying stages of decay are in the surface layer. The material is very porous, spongy, and matted with roots of sedges, swamp herbs, and bushy plants. Peat varies in thickness from 12 inches or less to 3 feet or more and rests on a mineral subsoil of yellow or bluish-gray sandy clay, silty clay, or heavy clay, which is mottled with gray and becomes more blue and more dense with increasing depth.

Several scattered areas are mapped in small swampy depressions and near the foot of wet slopes from a point near the mouth of the Cle Elum River westward. The total area is only 256 acres. Peat occurs in many small swampy depressions and seepy areas on slopes in the mountains and local stream valleys that are outside the area of the detailed survey and are not differentiated on the reconnaissance map.

This soil has little present agricultural value except for pasture. Several areas have been cleared of brush and timber and partly drained. It has been found that after the land is used for pasture a few years about one fair crop of oats can be grown without the aid of fertilizer.

MISCELLANEOUS SOILS AND LAND TYPES

A group of miscellaneous soils and land types includes a variety of materials that are not mapped in detail with respect to soil series and types or do not conform to the classification of soil series and types described in the foregoing pages. This land is dominantly nonagricultural or distinctly submarginal with respect to agriculture.

Stony and shallow soils.—Although these soil materials have a rather wide range in profile character, most of them represent shallow, stony phases of the soils with which they are associated. Extensive areas, associated with areas of the Manastash soils, occur in the northern and western parts of the Kittitas Valley, and smaller scattered areas are in the Manastash district.

These areas, locally known as scabland, consist of a very thin cover of brown loam or clay loam filled with coarse gravel and cobblestones, overlying the cemented-gravel beds typical of the Manastash soil. In many places a deeper soil cover of brown gritty loam occurs in narrow strips and low mounds with intervening barren areas of the exposed gravel substratum. This land is used for pasture, and the carrying capacity is very low (pl. 6, *B*). The relief ranges from gently sloping to steep and hilly. Where the land is smooth and deep enough for flood irrigation and where sufficient water at low cost is obtainable, an improved permanent pasture of white clover and mixed grasses might be established.

Other extensive areas occupy the slopes of Badger Pocket, and numerous areas in The Park district represent shallow and stony soil materials of the Selah series. On Lookout Mountain, Swauk Prairie, and Thorp Prairie, bodies of stony and shallow soil materials of the Swauk series are included. Less extensive areas occupying narrow strips along breaks of coulees, eroded spots, and areas on the margin of the Kittitas Valley associated with areas of steep broken land and scabland represent other inclusions.

These lands for the most part are unsuited to cultivation, and the few scattered areas that are under irrigation are best utilized for permanent mixed grass and clover pasture.

Stony and shallow soils (timbered).—This type of material includes large areas of variable but largely stony and shallow soil materials in the timberlands west of Thorp Prairie and on Lookout Mountain. Small areas are widely scattered in the timbered part of the area covered by the detailed survey. For the most part the soil materials are underlain at a slight depth by basalt bedrock, and very stony areas and rock outcrops are common.

This land is best utilized for grazing and forestry.

Riverwash.—Riverwash consists of gravel bars and sandy and excessively gravelly and cobbly materials bordering the larger streams and occupying dry beds of coulees and other drainage channels. In many places these materials are imperfectly assorted and are traversed by overflow stream channels. They are subject to overflow during periods of flood or freshets, are coarse-textured, loose, and unstable, and are unfit for agriculture. They have little value for grazing except for incidental association with shade and streams or water holes in connection with the maintenance of livestock.

Numerous small strips consisting of old stream-laid gravel bars occur along many spreading channels of Wilson and Nanum Creeks, in association with the Wenas and Naches soils.

Several small areas mapped along the Columbia River consist of light-gray very fine sand that has been blown from the river channel during low water. It lies above the present high-water stage of the river and has a cover of sagebrush, rabbitbrush, and grass. The surface is nearly flat, except for the small hummocks formed by drifting sand.

Steep broken land.—This land type includes areas that are unfit for cultivation because of steep and rough broken relief, in some places associated with shallow soil and rock outcrops. It differs little from rough mountainous land, except that it is mainly treeless and occurs under a more arid climate and at a lower general elevation. The natural line of demarcation between these two land types is very indefinite, and boundaries are somewhat arbitrarily drawn because the limit of the timber cover is irregular. Groves of scattered yellow pines occur on protected north and east slopes, and a few trees grow along coulees well outside of the timbered area. Large areas of steep broken land occur on the ridges, along canyons, and in deeply entrenched drainage courses of the semiarid eastern part of the county. On the reconnaissance map the smoother areas of scabland and stony and shallow soils are included with this land type. Small areas of steep broken land occur on the lower hills, escarpments, and breaks of canyons and coulees in the eastern part of the detailed survey.

This land includes a number of types of soil material, and the sagebrush and grass cover varies according to exposure, elevation, and depth of the soil as well as with the extent to which it has been grazed by livestock. In general, the grass cover is better on north and east slopes, at higher elevations, and in the arid lands near the western margin of the timberless area. Most of the south and west exposures are severely eroded, but here the scant growth consisting mainly of downy chess or cheatgrass (*Bromus tectorum* L.) furnishes early grazing.

Owing to adverse topography, this land type is unsuited to agriculture and is best utilized for grazing under conservative use and measures of control.

Rough mountainous land.—As mapped, rough mountainous land includes the timbered lands of the mountains, in the western and northern parts of the county, which constitute more than one-half of the total area. These areas are generally dissected by canyons, ravines, and stream courses, and the relief, for the most part, is steep and unfavorable for cultivation. Included with rough mountainous land on the reconnaissance map are small areas of gentle mountain slope and local stream-valley land that are capable of cultivation. Such areas, however, are isolated and chiefly inaccessible, and most of them lie within the national forests.

The soils of this land type are not classified. They are chiefly thin, stony, and broken by outcrops of the underlying rock.

Rough mountainous land is of value for the production of timber, for summer grazing, and for recreational purposes. As watersheds, it is of inestimable value, and as such it warrants the most complete protection from fires and erosion.

Scabland.—The type commonly called scabland consists of very shallow and stony areas occupying eroded hilltops and slopes of ridges in the timberless eastern part of the county. The soil material, mainly of the Simcoe series, is thin and stony. Broken slabs of basalt lie over the surface, or basalt bedrock is exposed in outcrops. Reddish-brown heavy clay fills the spaces between the broken rocks. As mapped in the detailed survey, bodies of scabland are entirely nonarable, except for scattered areas of soil so small as to be of no value as farm land. In the large area of nonirrigable,

nonagricultural, dry range lands shown on the reconnaissance map, isolated bodies of the shallow Renslow and Selah soils and of Simcoe stony clay are included. Scabland is used only for grazing.

The vegetation on scabland consists of a sparse growth of grasses, scattered sagebrush, and low-growing arid-land shrubs. The native bunchgrass and several small native grasses persist at higher elevations and on north slopes, but, owing to overgrazing, the small annual introduced, downy chess (known as cheat grass), is dominant.

The grazing value of the sparse grass is good, but the carrying capacity is very low. The range lands are owned or leased in large areas and are used mainly for grazing bands of sheep in the spring, when the cheat grass is green, and in late fall after the sharp rough seeds have fallen out.

Rough broken land and scabland.—As its name indicates, this classification group is essentially a complex. It consists of rough broken areas dominated by steep and, in many places, eroded slopes but includes smooth rounded summits of ridges and hilltops. The soil materials are generally shallow and in many places stony and are associated with areas of scabland occupying ridge tops and eroded slopes in which the surface is partly covered with slabs of basaltic rock and broken by outcrops of basaltic bedrock. In the areas of scabland the thin soil materials are dominantly related to those of the Simcoe series, whereas some of the materials of the lower slopes are related to those of the Renslow and associated soils. The materials occur under low rainfall and are covered with only a sparse grassland vegetation, together with a few shadscale, sagebrush, and associated shrubs. Owing to adverse topography and shallow stony character, this land is of little agricultural significance, but it furnishes a small amount of early spring pasture that is utilized by sheep.

Renslow-Selah loams.—This complex, as shown on the reconnaissance map, comprises mainly Renslow loam and Selah loam, together with some marginal areas of stony and shallow soils and narrow strips of Esquatzel soils along drainageways. With a few exceptions, these lands lie above any possible extension of irrigation.

The area of about 2,500 acres on the top of Manastash Ridge, 6 miles south of Ellensburg, consists of Renslow loam and receives sufficient precipitation to produce wheat, yields of which range from 10 to 20 bushels an acre. One small area along Burbank Creek is used for rye for winter feeding on a sheep ranch. A part of the area at Roza is irrigated from a spring. Small acreages at Roza and at the mouth of Squaw Creek are irrigated with water pumped from the Yakima River. The remaining areas of this group of soils lie where there is insufficient moisture for successful dry farming and are used only for grazing. The Squaw Creek basin was at one time taken up in homesteads and later abandoned.

Valley land, undifferentiated.—This land type includes stream bottoms, terraces, and lower foothill slopes of the valleys of the mountain streams. It comprises principally soils of the Pend Oreille, Teanaway, Springdale, Roslyn, Yakima, and Wenas series, and riverwash.

The season is too short for profitable farming in the mountain areas, and the larger areas lie within the national forests. Part of the

land along the Teanaway River, however, is occupied by farms and small livestock ranches.

Included areas on the west bank of the Columbia River, in the northeastern corner of the county, consist principally of Yakima very gravelly sandy loam, scabland, and riverwash, together with small bodies of Onyx loam.

PRODUCTIVITY RATINGS

As stated previously, Kittitas County includes an area that covers a wide range of climatic conditions, especially precipitation and humidity; native vegetation; topographic features and elevation; geological material; and consequently soil conditions. Added to these diverse factors of the natural environment that affect the productivity of the soils are the varying artificial or man-made factors of irrigation, water supply, and management. The timing and amount of irrigation water added, drainage conditions, practices of management, such as rotation, fertilizer, and the kind of crop, and the nature of the season, each has a tremendous influence on productivity. Although differences in natural environment are usually correlated with units of soil classification, the effects of differences in management and in proficiency in the use of water by individual farmers on productivity are not so readily recognized or recorded in irrigated areas. This fact, together with the fact that differences in elevation and topography from one site to another in the county appear to affect production significantly, even where they seemingly do not have any marked effect on soil morphology, makes the preparation of productivity ratings for the soils and land types in Kittitas County extremely difficult. In general, under similar irrigation practices, the soils of the western humid and subhumid timberland districts produce lower yields than those of the semiarid lands, because of lower inherent fertility, a shorter growing season, and lower mean annual temperatures.

Much additional time and expense would be required to collect sufficient data for detailed productivity indexes.

The following tabulation gives the range in yields of crops in the county, and table 7 gives a summary of the statements in the text concerning soil-crop relations.

Crop:	*Approximate acre yield (bushels)*
Wheat (irrigated and in rotation)	[1] 20–80
Wheat (dry-land farming): [2]	
Umtanum district on Manastash Ridge	6 20
Manastash district (above the ditch)	20–40
Thorp Prairie	6–20
Swauk Prairie	15–30
Oats (irrigated)	[3] 70
Barley	40–75
Peas for seed (irrigated)	20–75
	Tons
Alfalfa (irrigated)	1–6
Mixed grass and legume hay (irrigated)	1–5
Potatoes (irrigated)	5–20
Seed potatoes (dry-land farming)	1–2½

[1] A yield as high as 101 bushels has been reported.
[2] Summer-fallow every other year.
[3] Yield may be as high as 140 bushels.

TABLE 7.—*Comparative suitability of the soils of Kittitas County, Wash., for indic*

Soil	Irrigation farming (under prevailing practices)					Dry farming (under prevailing practices), wheat
	Wheat	Oats and barley	Alfalfa	Mixed grasses and legumes	Potatoes	
Ahtanum loam	Poor to good	Poor to good	Poor to good	Poor to good	Poor to good	
Bertolotti fine sandy loam	Poor to fair	Poor to fair	Poor to fair	Poor to fair	Poor to fair	
Bertolotti loam	do	do	do	do	do	
Cle Elum fine sandy loam						
Cle Elum loam	Fair	Good		Good	Fair	
Esquatzel very fine sandy loam	Good	do	Good	do	Good	
Garrison fine sandy loam	Fair	Fair to good	Fair	Fair to good	Fair	
Kittitas silt loam	Fair to good	Good	do	Good	Fair to good	
Latah clay loam	do	do	do	do	Fair	Good
Manastash fine sandy loam	Good	do	Good	do	Good	
Manastash loam	do	do	Fair	do	Fair to good	
Naches fine sandy loam	Fair to good	Fair to good	Fair to good	Fair to good	do	
Naches clay loam	do	do	do	do		
Nanum loam	do	Good	Poor to fair	do	Poor to fair	
Onyx fine sandy loam	do	Fair to good	Good	Fair	Good	
Onyx loam	Good	Good	Very good	Good	do	
Peat						
Pend Oreille loam	Fair	Fair	Fair	Fair	Fair	
Peoh clay	Fair to good	Good		Good		
Peoh loam	Fair	do		Fair to good		

TABLE 7.—*Comparative suitability of the soils of Kittitas County, Wash., for indicated ty*

Soil	Irrigation farming (under prevailing practices)					Dry farming (under prevailing practices), wheat
	Wheat	Oats and barley	Alfalfa	Mixed grasses and legumes	Potatoes	
Peoh silty clay loam	Fair to good	Good		Good		
Quicksell loam	Poor	Poor	Poor	Poor	Poor	
Reeser loam	Good	Good	Fair	Good		
Renslow loam	do	do	Good	do	Good	Good
Renslow-Selah loams (reconnaissance map).[1]						Fair to good
Riverwash						
Roslyn fine sandy loam	Fair	Fair	Fair	Fair	Fair	
Rough broken land and scabland (reconnaissance map).						
Rough mountainous land						
Scabland						
Selah loam	Fair to good	Fair to good	Fair to good	Fair to good	Fair to good	
Selah loam, terrace phase	do	do	do	do	do	
Simcoe clay	Good	Good	Fair	Good		
Simcoe stony clay	Fair	Fair	do	Fair		
Springdale gravelly sandy loam	Poor to fair	Poor to fair	Poor to fair	Poor to fair	Poor to fair	
Steep broken land						
Stony and shallow soils						
Stony and shallow soils (timbered).						
Swauk loam	Fair to good	Fair to good	Fair	Fair to good	Fair to good	Good
Taneum clay loam	Good	Good	Good	Good	do	do
Taneum clay loam, eroded phase	Fair to good	Fair to good	Fair	Fair to good		Fair
Taneum silty clay loam	Good	Good	Good	Good	Fair to good	
Teanaway loam	Fair	Fair	Fair	Fair	Fair	

Teanaway loam, terrace phase	do	do	do	do	do	
Valley land, undifferentiated (reconnaissance map).						
Volke sandy clay loam	Fair to good	Fair to good	Fair	Fair to good		
Volperie loam						
Volperie loam, terrace phase						
Waha clay	Fair	Good		Good		
Wenas gravelly loam	Poor to fair	Poor to fair	Poor to fair	Poor to fair		
Wenas loam	Fair to good	Fair to good	Fair to good	Fair to good	Fair to good	
Woldale clay loam	Good	Good	do	Good	Fair	
Woldale clay						
Yakima fine sandy loam	Fair	Fair to good	Fair to good	Fair to good	Fair to good	
Yakima loam	Good	Good	Good	Good	Good	
Yakima very gravelly sandy loam.						

[1] Mostly above irrigation.

LAND USE AND AGRICULTURAL METHODS

The tillable soils of the treeless semiarid and subhumid lands of the county are fertile and productive. The content of organic matter and nitrogen, which is naturally low in the light-colored soils, is improved and maintained by the growth of alfalfa or other legumes.

The reddish-brown or dark soils of the uplands and terraces of the Pend Oreille, Springdale, Roslyn, Garrison, and Volke series, which lie within the timbered area, have moderate capacity for the production of crops. The gray soils of the timberlands, however, are somewhat leached and infertile and are better suited to forestry than to agriculture.

All the dark imperfectly drained soils except peat are, when properly drained, fertile and productive of such crops as grass-hay crops, clover, and grain, which are adapted to lowland conditions.

The sparse grass cover of the semiarid ranges has been depleted by overgrazing; and, although the grasses are nutritious, the carrying capacity of the ranges is very low. These areas are suitable only for short periods of spring and fall grazing.

Grasses and other forage are more abundant in the open timber and park lands, but little forage for livestock is afforded in the thick coniferous forests of the humid mountain slopes. The best grazing lands are in the subhumid zone along the margin of the timber.

Native grasses apparently grow equally well on all soils and land types except the very shallow scabland. Their growth and distribution is controlled mainly by temperature and supply of moisture. The grasses on the neutral or basic soils of the subhumid and semiarid zones are the most nutritious.

Coniferous forest trees also grow much the same on the soils of the subhumid and the humid areas. The growth and distribution of the different species are governed largely by elevation, exposure, temperature, and moisture conditions.

As stated, the agriculture of Kittitas County is more closely adjusted to climate, topography, water supply, and drainage conditions than to the wide variety of different soil types. In general, the common farm crops adapted to the region are grown on all tillable land where irrigation is available and moisture and drainage conditions are favorable.

A large number of the farmers are efficient and progressive and make intelligent use of their land. Although several desirable adjustments and improvements should be made in farming methods, the changes will probably be carried out only when improved market conditions and changes in land tenure give the proper incentive. Under present conditions it is necessary on many farms to grow certain crops, even though they may be poorly suited to the soil type of the farm.

In general the soil fertility can best be maintained by keeping a sufficient number of livestock, by growing alfalfa, red clover, or other legumes in rotation, and by the application of barnyard manure and the winter feeding of livestock on fields. The profitable use of

commercial fertilizers is limited largely to superphosphate, which supplies both phosphorus and sulfur to the older farm lands. In some places the use of ammonium sulfate for potatoes is desirable. Many farmers use complete fertilizers for this crop.

Loss of the surface soil by both wind and water erosion on the sloping lands under irrigation can be most effectively controlled by keeping this land in sod-forming crops. The greater part of the new land under the Highline Canal in the eastern and southern parts of the Kittitas Valley should be kept in hay crops and permanent pasture, and the cash crops, such as grain, peas, and potatoes, should be grown only on the more nearly level land.

The United States Soil Conservation Service established an erosion control project in the Kittitas Valley in 1936 and is giving aid and advice to farmers on methods of erosion control.

There are considerable areas of land composed of the stony and shallow soils, particularly in the Badger Pocket and Reeser Creek districts, that are unfit for cultivation but for which an abundant supply of water is available. If water were delivered at sufficiently low cost, large acreages of this land could be utilized profitably in permanent pasture. A mixture of grass and legume seed well suited for this purpose, recommended by the Washington Agricultural Extension Service, is as follows: 4 pounds of smooth bromegrass, 2 pounds of English ryegrass, 2 pounds of Kentucky bluegrass, 3 pounds of orchard grass, 3 pounds of meadow fescue, 3 pounds of tall meadow oatgrass, 2 pounds of alsike clover, and either 2 pounds of White Dutch clover or 1 pound of ladino clover.

The soil productivity of many farms would be increased if more red clover or sweetclover were grown in rotation on land that is poorly suited to alfalfa.

Yields of alfalfa in the Kittitas Valley could probably be increased by the use of seed of more productive varieties and strains. Several farmers have collected seed from old plants remaining along fences in an effort to renew their fields with the old strain of Common alfalfa that was first grown in the valley. The northern-grown Common variety is best suited to the deep, well-drained soils, and the variegated varieties with spreading root systems are recommended for shallow and imperfectly drained soils.

Weed-control districts have been organized in the Kittitas Valley for the purpose of combating the numerous species of noxious weeds that are prevalent on the older farm lands. Spraying with chemicals, such as sodium chlorate, has proved effective in destroying weeds along ditchbanks and in small patches in fields, but this is expensive. For weed eradication in fields, crop rotation and careful cultivation are more feasible though less effective.

IRRIGATION, DRAINAGE, AND ALKALI

There is considerable need for improved drainage and more efficient use of irrigation water in the Kittitas Valley, particularly in the district lying northeast and southeast of Ellensburg. Many of the older farms have individual creek rights. As there are no storage reservoirs on the creeks, the water flows down many dividing chan-

nels and through the smaller irrigation ditches during the winter and early spring, when it is not needed for irrigation, subirrigating the poorly drained tracts and saturating the substratum over large areas. During July and August, when water is most needed for irrigation, the flow becomes low or stops completely.

The drainage problem generally is one that calls for individual attention on each farm. The general slope of the land in the imperfectly drained areas ranges from 25 to 100 or more feet to the mile, a sufficient gradient to allow much effective drainage by short local drains discharging into natural channels. Larger intercepting drains are needed under the lower slopes of the Edgemont and Badger Pocket districts to protect the more nearly level lands from seepage that comes from irrigation of the hill slopes.

Except in the more arid part of the county, irrigation is largely supplemental in character and is most needed in late summer. Where water is most abundant in the spring but is not needed, it is wasted, resulting in unnecessary leaching of the soil and seepage of the surrounding lands.

Because of the prevalence of shallow surface soils, clay subsoils, and impervious substrata, resulting in limited storage capacity of effective moisture in the upper part of the soil, light and frequent irrigations are necessary on most of the land.

In field distribution of water, the corrugation method with small closely spaced ditches is in general use. This method is best suited for steep or moderately sloping land and for a small continuous flow of water. On sloping land the general practice of running corrugations straight down the slope is undesirable, as it causes unnecessary erosion. Placing the corrugations around the slope with the contour of the land or diagonally down the slope with a moderate gradient are much better methods, if the head ditches are stable and the flow of water is carefully tended to prevent overflow and the washing out of ditches.

Earth head ditches should be made stable and kept free from weeds by grass sod, preferably of bromegrass or Kentucky bluegrass mixed with orchard grass or meadow fescue. Cheap wooden flumes with outlets for individual corrugations are to be recommended.

On the nearly flat or gently sloping lands, if there is a sufficient head of water, the method of flooding between small lateral ditches is much faster and more efficient for hay and pasture.

"Alkali" is the common term applied to all harmful soluble salts that accumulate in the soil. "Saline" is a more accurate term applied to lands of this class, as generally a large proportion of the salts are neutral salts, mainly magnesium sulfate (Epsom salt), sodium sulfate (Glauber's salt), and sodium chloride (common salt). Sodium bicarbonate (baking soda) and sodium carbonate (washing soda) also occur in varying amounts. The sodium carbonate has a corrosive alkaline action on organic matter, which gives rise to dark-brown or black discoloration on the surface or within the soil in the presence of moisture and is known as "black alkali." It is much more toxic to plants than other salts. The sodium bicarbonate is in itself less toxic but under field conditions is readily converted into the more highly injurious sodium carbonate.

Under conditions of low rainfall, impaired drainage, and excessive evaporation from the surface soil, the mineral salts in solution are carried upward through the soil by capillary movement from the ground water below and become concentrated at or near the surface. If the process is reversed by adequate irrigation and drainage, so that the water moves continuously downward and is removed in drainage channels, no salts will accumulate and those already in the soil will be gradually leached away.

It is more practicable to protect lands from accumulations of salts by proper irrigation and drainage than to reclaim them after they have become saline or alkaline. The greater part of the saline land of the Kittitas Valley can, however, be reclaimed, as is evidenced by successful efforts of certain farmers whose productive fields are in striking contrast with adjacent nonproductive saline land of the same soil type.

The ease with which soil can be reclaimed from excessive accumulations of salts depends on the permeability of the soil and the rate at which the water can move laterally to natural or artificial drainageways. The most serious handicap in leaching the salts from alkali land is the deflocculating effect of sodium carbonate. This compound causes the fine particles of the soil, which are normally bound together in granular aggregates, to disperse as extremely fine particles, and the soil runs together and becomes puddled and impervious when wet and bakes hard when dry. This effect is most marked after most of the salts have been leached from the soil. Heavy applications of sulfur or gypsum have proved effective to correct this deflocculated, impervious condition, but extensive use is too expensive except on small slick spots, as the affected areas are called.

Fortunately the deflocculating effect of the salts in the Kittitas Valley is much less pronounced than in the soils that contain more colloidal clay, and slick spots are commonly of mild character and small extent. They will disappear in time with the growth of alfalfa or sweetclover or with applications of barnyard manure followed by careful irrigation.

The deep smooth-textured soils of the more nearly flat valley areas developed on loessial materials have a very pronounced tendency to accumulate salts wherever the depth to ground water is slight. These soils are underlain for the most part by fine-textured valley-filling sediments through which ground water moves laterally at a very slow rate. Conditions are very favorable for capillary movement, and water rises, like oil in a wick, to the surface soil, where evaporation concentrates the salts.

The Esquatzel soil will accumulate alkali wherever it is subjected to seepage of ground water from irrigation of higher lands. The Ahtanum soil was for the most part affected by salts before the region was settled. It includes almost all of the nonproductive alkali lands of the valley. The Kittitas and Woldale soils are affected to a less extent.

In protecting the Esquatzel soil from becoming saline or reclaiming the Ahtanum soil from accumulation of salts, it is generally necessary to cut off the movement of ground water from the adjacent sloping irrigated uplands by deep intercepting drains. These soils have a

high potential value as farm land and should be producing the cash crops, so that the shallow erodible soils of the uplands could be used only for hay and permanent pasture.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of weathering and development acting on parent soil materials deposited or accumulated by geologic agencies. The characteristics of soil at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the material. External climate, although important in its effects on soil development, is less so than internal soil climate, which depends not only on temperature, rainfall, and humidity, but on the physical characteristics of the soil or soil material and on the relief, which, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

The soils of Kittitas County have developed in several climatic and environmental zones and belts. Botanists have recognized and defined seven general types of vegetation or broad plant associations in the Pacific Northwest,[7] of which four are prominent in this county. These four are sagebrush (northern desert shrub), bunchgrass (Pacific grassland), yellow pine and Douglas-fir (western pine forest), and spruce fir (northern coniferous forest). These associations are not distinct but grade into one another, and, although each may be considered to occupy a zone, the zones are not definite. The zones occupied by these plant associations coincide in a general way with climatic belts and with rather distinct soil belts.

The northern desert shrub association occupies the lower and drier eastern part of the county. This zone may be subdivided on the basis of climate into a narrow belt along the Columbia River and a somewhat higher belt that occupies most of the southeastern third of the county, including the greater part of the Kittitas Valley. The former is characterized by comparatively mild winters, hot summers, and an annual precipitation of about 6 inches; the latter, by somewhat lower temperatures and higher rainfall—from 8 to 12 inches. Some bunchgrass occurs in this belt. The zone dominated by bunchgrass and practically without sagebrush is narrow and irregular, and it blends with the lower part of the yellow pine and Douglas-fir zone, in which ponderosa pine (western yellow pine) is prominent. This transitional zone is semiarid to subhumid and lies along the lower edge of thicker forests. It skirts the northern and western margins of the Kittitas Valley and occupies the Swauk and Thorp Prairies and Lookout Mountain. Here the precipitation ranges from about 12 to 22 inches.

The yellow pine and Douglas-fir zone grades into the spruce-fir zone at higher elevations. These two forest zones occupy the valley of

[7] SHANTZ, H. L., and ZON, RAPHAEL. NATURAL VEGETATION. GRASSLAND AND DESERT SHRUB. U. S. Dept. Agr. Atlas of Amer. Agr., 29 pp. illus. 1924.

the upper Yakima River and extend to Keechelus Lake and up the mountain slopes to elevations of 4,000 feet and more above sea level. The annual precipitation ranges from 22 to 60 inches or more.

The soils are developed on parent materials having a wide range. Yakima basalt, which underlies the eastern half of the county, weathers too slowly under a semiarid climate to keep pace with erosion, so that normal zonal soil profiles do not form from residual materials. In the subhumid and humid parts the soils have developed largely in place from sandstones of the Ellensburg and Roslyn formations and Easton schist. The important agricultural soils, however, are developed on transported materials consisting of loess, old alluvial valley-filling deposits, glacial till and outwash materials, mountain outwash, alluvial-fan materials, and recent stream-valley deposits.

The most striking characteristic of the climatic environment common to the entire county is that most of the precipitation falls in winter and the summer season is almost rainless. Even in the humid part, the soils of the uplands become very dry during late summer and early fall. An accumulation of lime in the semiarid soils is comparatively slight and occurs at greater depths than in soils developed in the semiarid area under summer rainfall.

A large proportion of the precipitation falling in winter enters the soil, because the rains are gentle and much of the snow melts slowly in early spring. The ground is usually frozen for only a short time in the middle of the winter, allowing the scant supply of moisture to penetrate to a considerable depth.

The Gray Desert soils of the low belt along the Columbia River, which are represented by the Quincy, Ephrata, Sagemoor, Burke, and other series in adjacent Grant County,[8] are absent in Kittitas County, where this zone is occupied dominantly by rough broken land and scabland.

The grayish-brown soils of the eastern part of the Kittitas Valley and other places in the semiarid sagebrush and bunchgrass areas are developed on loess and old valley-filling deposits. Renslow loam developed on loess, most nearly represents the present normal zonal soil, probably representing the great soil group of Brown pedocalic soils.

Typical virgin Renslow loam has a 3-inch surface layer of grayish-brown smooth loam containing a few coarse gritty fragments of basalt. It is slightly compact and has no definite structure. The subsurface layer, which extends to a depth of about 14 inches, is brown smooth loam containing a high proportion of very fine sand. This material is moderately compact and somewhat porous and vesicular and lacks definite structure, although it has widely spaced vertical cracks. It breaks into large soft massive blocks that are easily crushed into a single-grain condition, although a few irregular friable clods persist. Below this and continuing to a depth of 24 inches the soil is similar but slightly lighter colored material. This is underlain to a depth of about 36 inches by a light-brown smooth compact loam breaking into irregular chunks that are fairly friable and easily crushed to single grains. This material gives way to light

[8] STRAHORN, A. T., and others. SOIL SURVEY (RECONNAISSANCE) OF THE COLUMBIA BASIN AREA, WASHINGTON. U. S. Bur. Chem. and Soils, ser. 1929, No. 28, 55 pp., illus. 1934.

slightly grayish brown smooth very compact heavy loam, breaking into irregular clods of variable size down to small aggregates. These are rather friable, considering the degree of compaction. Between depths of 52 and 58 inches the material is light grayish-brown soft slightly compacted loam containing some almost spherical compact lumps. This layer contains sufficient accumulated lime to produce slight to moderate effervescence with acid. The underlying material is light grayish-brown smooth-textured loess that does not effervesce.

This profile is peculiar to the soil of loessial origin. The other strongly developed soils of the uplands in this zone, such as Selah loam and Manastash loam, have heavy clay subsoils. These soils, however, are comparatively shallow and are developed over substrata of materials that are sufficiently impervious to hold moisture in the subsoil and to cause increased hydrolysis and the consequent development of clay horizons. This process is suggested by the fact that in included areas of Selah soil, where the substratum is loose and pervious, the clay subsoil has failed to develop.

The beds of caliche that characterize the upper part of the substrata underlying the Selah soils may not be part of the present soil profile but relics of past conditions. The occurrence of rounded fragments of caliche with glacial outwash gravel of the Ephrata soils of Grant County and beds of caliche underlying the glacial lake sediments near Kiona in Yakima County indicate that at least some of these deposits are of considerable age.

The heavy clay horizon of Selah loam reaches its most pronounced development directly over compact and hard layers of caliche. This may be due to increased hydrolysis in such situations caused by the concentration of percolating moisture over the comparatively impervious caliche.

As stated, the basalt rock does not weather rapidly enough under an arid or a semiarid climate for the development of a normal soil profile, and as a result there are large areas of basaltic scabland on the ridges of eastern Kittitas County where a thin reddish-brown gritty clay has formed on and between subangular fragments of weathering basalt. Other areas of soils from basalt are represented by shallow and stony soils of the Simcoe series. The Simcoe soils are developed in the transitional zone between the semiarid and subhumid climatic belts and are of very limited extent in Kittitas County because of the narrowness of this zone and the steep relief. They are developed around the northern margin of the basin of the Kittitas Valley and as isolated areas at the northern border of Swauk Prairie and in the high hills north of the Teanaway River.

The Teanaway, a gray podzolic soil, is developed on glacial till similar to that underlying the Swauk soil, with which it is associated, but under forest cover.

Under a forest cover of yellow pine and Douglas-fir, the surface of virgin Teanaway loam, where observed in a typical locality, is covered with a ½-inch layer of decomposing pine and fir needles. The ½-inch surface layer of mineral soil is dark grayish-brown very light and compact organic loam. This rests on a 1- to 2-inch layer of gray slightly compact but very friable loam having a laminated to thin platy structure. The subsurface layer is light grayish-brown

loam with a slight pink tint. It is moderately compact and is massive and vesicular, breaking into large friable chunks. Some pebbles and angular rock fragments are present in this layer. The upper subsoil layer, between depths of 17 and 26 inches, consists of light grayish-brown or tan massive finely vesicular loam, breaking into irregular friable chunks that can readily be crushed into soft granules and crumbs. This horizon is mottled with brown and grades into a horizon of light grayish-brown very compact massive vesicular loam mottled with gray and a darker shade of brown. Between depths of 42 and 56 inches the subsoil is rich-brown clay or slightly sandy clay. This material is very compact and hard, breaking into irregular clods and small aggregates slightly mottled with gray. It grades below into boulder till.

The normal regional soil of the more humid part of the county near Easton is well typified by Pend Oreille loam, developed principally on glacial boulder till. The virgin Pend Oreille loam occurs under a rather heavy growth of mixed coniferous forest with some deciduous underbrush. The annual precipitation ranges from 23 to 60 or more inches. Generally a heavy snowfall lies on the ground in the timberland until the middle of spring.

The forest floor is covered with a 1-inch layer of decomposing leaves of pine, fir, and tamarack. Immediately beneath this is a ½-inch layer of dark grayish-brown or nearly black organic loam that is very light and fluffy. Just below this is a definitely podzolized A_2 horizon of grayish-brown fine sandy loam containing many white siliceous grains. It is light in weight and very loose and ashy. Below this and reaching to a depth of 18 inches is a subsurface layer of light reddish-brown light-textured loam containing much gritty material and small decomposing pebbles and embedded pieces of gravel. This horizon is but slightly compact and almost without structure. The subsoil is light reddish-brown compact loam mottled with gray and deeper red. It breaks out in irregular clods, which crush to small fragments and granular aggregates. At a depth of 36 inches it rests on the parent material, which, to a depth of 50 or more inches, is reddish-yellow fine sandy loam with decomposing pebbles embedded. This material is slightly to moderately compact and grades into coarse till containing many boulders.

The Pend Oreille soil closely resembles the soils developed under higher rainfall and milder climate in the western foothills of the Cascade and Olympic Mountains. Apparently it is less acid and more productive than the gray Teanaway soil developed under lighter precipitation and more open forest.

The Taneum soils have developed in small areas on the foothills along the margin of the semiarid zone where massive beds of tuffaceous sandstone have weathered to a considerable depth, possibly under some earlier climatic conditions. These dark-colored soils most typically occupy the north and east slopes, where the precipitation is most effective and the grass and herbaceous growth most abundant.

No Chernozem soils occur in this area. The dividing line between the pedocalic and pedalferic soils lies just west and north of Ellensburg on approximately the 10-inch isohyetal line.

The Manastash, Simcoe, Waha, and Taneum soils, all having a pronounced development of clay subsoil, lie on the pedalferic side of this line.

The Manastash soils are widely distributed in the western and central parts of the Kittitas Valley and are developed on cemented gravel beds on benches or terracelike remnants of the older floor of the basin of the Kittitas Valley. The loam is the dominant type of the Manastash series.

The Naches soils are developed on old valley-filling fan deposits. They are characterized by rather shallow and, in many places, gravelly surface soils and compact heavier textured subsoils, which overlie a substratum of brown-stained coarse gravel.

The Volperie soils occur only in a comparatively small area on the mountain foothills and terraces between Cle Elum Creek and Little Creek and are developed on material derived from Easton schist. These inextensive soils are of very little agricultural significance. Most of the merchantable timber has been logged off, but none of the land has been cleared for cultivation.

The Swauk soils, which lie in the zone of Prairie soils, are developed most typically on glacial till, but the subsoil clay horizon is solonetzlike in character. The mechanical analyses of Swauk loam, the only member of this series occurring in the county, is given in table 8.

TABLE 8.—*Mechanical analyses of Swauk loam in Kittitas County, Wash.*

Sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
5519119	0- 4	0.6	2.0	4.5	14.9	14.9	46.1	17.0
5519120	4 12	.4	1.5	4.4	15.1	14.4	47.1	17.1
5519121	12-20	.4	1.3	3.3	14.0	15.2	47.0	18.8
5519122	20-27	.5	1.4	3.2	12.3	15.0	48.8	18.8
5519123	27-28	.2	1.1	2.4	8.9	11.3	39.6	36.5
5519124	28-42	.2	1.0	2.0	7.7	11.1	37.4	40.6
5519125	42 60+	.9	2.5	6.1	18.6	11.0	36.5	24.4

The soils of the Onyx series consist of recent local alluvium washed from the uplands and deposited as alluvial fans on the lower lying lands by the runoff waters from large coulees.

The Yakima soils occupy the larger part of the alluvial bottom lands of the Yakima River and its larger tributaries. They are characterized by comparatively recently deposited brown soil material overlying loose stream-laid gravel. Areas of these soils occur from the large lakes and the branches of the Teanaway River to the head of the canyon of the Yakima River south of Ellensburg. The stream bottoms are broken in many places by gravel bars, stream channels, sloughs, swamps, and abandoned channels that have been partly filled. Although the general relief is gently sloping with the gradients of the streams, a slope ranging from 15 to 50 feet to the mile, slight differences in level, commonly bounded by low escarpments, are common. The valley of the upper Yakima River is heavily timbered with cottonwood, pine, and brush, except where cleared for cultivation. The valley of the Teanaway River and the Kittitas Valley are mostly open, except for a fringe of deciduous timber along the stream bottoms and sloughs.

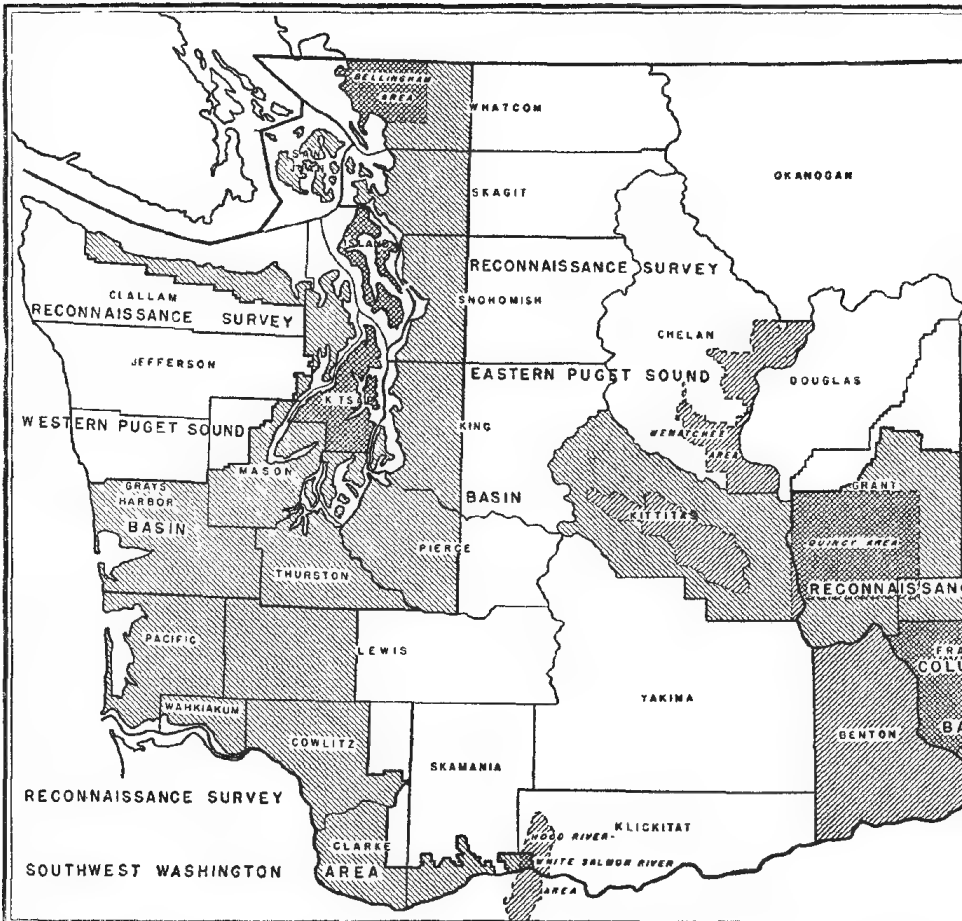
The soils of Kittitas County that are intrazonal in character are of wide variety and distribution and include the larger part of the important agricultural lands. Shallow eroded areas occur in all the soils of the uplands.

Dark, imperfectly drained, and abnormally developed soils occur in all the basin lowlands and stream bottoms, as well as in depressions in the uplands. Small marshy areas are indicated by marsh symbols, but several well-defined Bog and Half Bog soils have been differentiated on the map. The soils of the Woldale and Peoh series and considerable areas of the Wenas soils are Wiesenböden soils and have well-developed glei horizons.

Areas of Solonchak are common in Ahtanum loam and also in small scattered spots in the Kittitas, Woldale, and Esquatzel soils. A peculiar hardpan cementation is developed intermittently in the most salty areas of the Ahtanum soil.

The slick spots in the saline soils are probably areas of imperfectly developed Solonetz caused by deflocculation, which takes place when the excess of salt is leached from the surface soil.

U. S. GOVERNMENT PRINTING OFFICE: 1944



Areas surveyed in Washington shown by shading. Detailed surveys shown by northeast-s
surveys shown by northwest-southeast hatching; cross hatching indicates areas

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Map of Kittitas County, Wash., showing topography and drainage.

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AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING
ROBERT M. SALTER, CHIEF
DIVISION OF SOIL SURVEY, CHARLES E. KELLOGG, CHIEF
MAP DRAFTING, J. W. McKERICHER, IN CHARGE

SOIL MAP

DETAILED-RECONNAISSANCE
KITTITAS COUNTY—SHEET ONE
WASHINGTON

WASHINGTON AGRICULTURAL EXPERIMENT STATION
EDWARD C. JOHNSON, DIRECTOR
L. C. WHEETING, IN CHARGE SOIL SURVEY

LEGEND

SEMIARID UPLANDS AND TERRACES

Renslow-Selah loams — RS

LOWLANDS AND STREAM BOTTOMS

Valley land (*Undifferentiated*) — Vd

MISCELLANEOUS LAND TYPES

Rough mountainous land — Rm

Rough broken land and Scabland — Rb

CONVENTIONAL SIGNS

CULTURE (*Printed in black*)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort

Secondary roads and Trails

Railroads: Steam and Electric

Bridges, Ferry

R.R. crossings, Tunnel

Fixed Dam, Seawall, Windmill

Boundary lines

CULTURE (*Printed in black*)

School, Church, Creamery, Cemeteries

Boundary lines

Triangulation station, Boundary monument, Oil or Gas wells

U.S. Township and Section lines, Recovered corners

Forest fire station, Airway beacon, Oil or Gas tanks

Transmission line, Oil or Gas pipe line

Mine or Quarry, Rock cutaway, Made land

Soil boundaries, Stony, Gravelly and Cherty areas

DRAINAGE (*Printed in blue*)

Streams, Springs, Wells, Flowing wells

Lakes, Ponds, Intermittent lakes

Unsurveyed and Intermittent streams

Water pipe lines, Canals, Ditches, Flumes

Swamp, Salt marshes

Submerged marsh, Tidal flats

The above signs are in general used on the maps therefrom the foreign agency in some maps of surface data.

RELIEF (*Printed in brown or black*)

Contours, Depression contours

Prominent hills, Mountain peaks

Sand Wash, and Sand dunes

Bluff, Escarpment, Mine dumps

The uncolored parts of the county are covered by a detailed soil map—see sheet two.

That portion of the map in the southeast corner which is without contours was compiled from a recent U. S. G. S. topographic quadrangle on a larger scale. It was impracticable to adjust the older U. S. G. S. quadrangles used for the remainder of the map to this recent work, or to bring them up to date.

Contour Interval
100 ft. — None
50 ft. — None

Area inspected by Macy H. Lapham, Senior Soil Scientist.
Soils surveyed by Leslie H. Smith, U. S. Department of Agriculture, in charge, and C. H. Dwyer and George Schafer, Washington Agricultural Experiment Station.

A. Hoen & Co., Inc.

Scale 125000
1 0 1 2 3 4 5 Miles
1 0 1 2 3 4 5 Kilometers
Contour interval 50 and 100 feet
Datum is mean sea level.

DIAGRAM OF TOWNSHIP

6	5	4	3	2	1	
7	8	9	10	11	12	
18	17	16	15	14	13	
19	20	21	22	23	24	
30	29	28	27	26	25	
31	32	33	34	35	36	

Polyconic projection, 1927 North American Datum.
Base map in part from U. S. Geological Survey Sheets.
10000 foot grid based upon Washington (South) system of plane coordinates.
Surveyed in 1935-37. Series 1937.

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SOIL MAP

DETAILED-RECONNAISSANCE
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